FINAL REPORT

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HABITAT USE BY FEMALE SAGE GROUSE

DURING THE BREEDING SEASON IN OREGON

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EXECUTIVE SUMMARY

Sage grouse (Centrocercus urophasianus) populations in Oregon declined approximately 60% and productivity measures decreased nearly 80% since the 1940s. Survival indices fluctuated but were unrelated to declines in sage grouse populations. Reduced productivity fully accounted for decreased sage grouse abundance since 1950. In 1985, the western sage grouse (C. u. phaios) was listed as a candidate for threatened and endangered status by the Department of the Interior. As a consequence, a study investigating habitat use by sage grouse during the breeding season was initiated in 1988. Two study areas were selected in southeastern Oregon: Hart Mountain National Antelope Refuge in Lake County and Jackass Creek in Harney County. These areas were selected for comparison because of long-term differences in sage grouse abundance and productivity. Since 1981, the only period for which comparable data were available, Hart Mountain has supported a greater abundance and had greater productivity of sage grouse than Jackass Creek.

Field work was conducted from summer 1988 through the breeding seasons (March-August) of 1989, 1990, and 1991. Female sage grouse were captured and fitted with solar-powered radio transmitters and monitored throughout the breeding season to determine habitats used for nesting and brood-rearing. Broodless hens were monitored from June through August to determine habitats used during summer. Selection of nesting and brood-rearing habitat by hens and summer habitat by broodless hens was investigated on 2 levels: selection for cover types and selection for habitat components within cover types. Eleven cover types were described on the basis of dominant shrubs and grasses. Each radio-marked hen location was classified into 1 of the 11 cover types. Boundaries of the area available for nesting, brood-rearing, and summer habitat on each study area were determined from locations of radio-marked hens. Habitat components (cover of shrubs, forbs, and grasses; height classes of shrubs and grasses; frequency of herbaceous vegetation; and vertical cover)

were measured at all nest and brood locations during 1989-1991 and at broodless hen locations in 1990. Within cover types at both study areas, habitat components were measured at randomly selected locations to characterize available nesting, brood-rearing, and summer habitats.

Sage grouse used a diversity of cover types for nesting at both study areas. However, big sagebrush cover types (mountain big sagebrush at Hart Mountain and mixed sagebrush at Jackass Creek) were used in greater proportion than available for nesting. Regardless of cover type used for nesting, nests (3-m^2 area at nest bush) had greater cover of medium height (40-80 cm) shrubs and tall residual grasses (>18 cm) than the area immediately surrounding nests (75-m^2) or random locations. This result indicated nest site selection was based on a relatively small area. Further, tall residual grass cover and medium height shrub cover were the habitat components that differentiated undepredated and depredated nests. These findings indicated a relationship between habitat structural characteristics and depredation of nests. Greater amounts of residual tall grass cover and medium height shrub cover at nests likely provided increased nest concealment from predators and resulted in greater nest success than at sites with less tall grasses and medium shrubs. These findings indicated the relationship between habitat components and depredation of nests was a structural relationship and not a plant community (cover type) relationship.

Hens with broods selected specific cover types at both study areas and selection changed over time. During the early brood-rearing period (hatching to 6 weeks), hens with broods selected cover types with the greatest availability of key forbs (defined by aggregate mass $\geq$1% or frequency $\geq$10% in crops of collected chicks) at both study areas. During the late brood-rearing period (7 to 12 weeks), availability of key forbs in cover types changed at

Jackass Creek and cover types used by hens with broods also changed. At Hart Mountain, forb availability did not change during the late brood period and consequently, cover type use did not change. Differences in habitat selection were observed between study areas. Within cover types at Hart Mountain, hens with broods did not select sites on the basis of forb availability. However, within cover types at Jackass Creek, forb cover was greater at brood sites than at random sites. Diets of chicks at Hart Mountain had a greater proportion of forbs and insects and less sagebrush than did diets of chicks at Jackass Creek. Further, home range size of hens with broods increased at Jackass Creek but decreased at Hart Mountain as summer progressed. These results suggested that forb availability was the primary influence for 1) cover type selection; 2) change in cover type use at Jackass Creek; and 3) differences in habitat selection, home range size, and diets of chicks between study areas.

Broodless hens (non-reproductive females) also selected particular cover types at both study areas during summer (June-August). However, broodless hens did not select for habitat components within cover types at Hart Mountain. At Jackass Creek, forb cover was greater at broodless hens sites than at random locations. Differences in habitat use between study areas was attributed to differences in forb availability between study areas. At Hart Mountain, forb availability was relatively high and broodless hens did not select sites within cover types on the basis of forb availability. However, at Jackass Creek, forb availability was low and broodless hens selected sites with greater forb cover within cover types. These results were similar to those of hens with broods. However, broodless hens used a greater diversity of cover types than hens with broods, presumably because habitat needs of broodless hens are less specific than that of hens with broods.

Sage grouse used a diversity of habitats throughout the breeding season and management of sage grouse must take into account all requirements for successful reproduction. Management of nesting habitat should concentrate on big sagebrush stands with an understory of native perennial grasses, whereas management of brood and broodless hen habitat should concentrate on maintenance of cover type diversity and availability of forbs. Therefore, an ecosystem or landscape approach is required for management to enhance sage grouse populations. Grazing by domestic livestock, fire, and sagebrush control are land management practices that influence cover type diversity and shrub and understory cover throughout sagebrush-steppe ecosystems. Grazing by domestic livestock potentially has the greatest impact on sage grouse habitat because it remains the most common and widespread use of rangelands in Oregon and is the principal land management practice and proximate factor that affects grass cover and height. Decreased grass cover at nests would likely reduce nest concealment from predators and result in increased vulnerability to predation. Disruption of fire cycles has resulted in increased shrub density (sagebrush and juniper) and decreased cover of tall bunchgrasses and forbs. Sagebrush control for agricultural production, increased livestock forage, urban development, and mining activities negatively impact sage grouse populations by loss of medium height shrub cover and tall grass cover for nesting and loss of cover type diversity and forb cover for brood-rearing.

Management activities need to be conducted on a ecosystem-wide basis, which incorporate virtually all of the major cover types present in sage grouse range. These management procedures should bring about the appropriate vegetative and community changes to provide suitable nesting, brood-rearing, and summer habitat for sage grouse.

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INTRODUCTION

Historically, sage grouse (Centrocercus urophasianus) were found wherever big sagebrush (Artemisia tridentata) occurred in the western United States and southwestern Canada (Klebenow 1985, Roberson 1986). Conversion of native rangelands associated with settlement, agricultural production, and livestock grazing contributed to reduction and elimination of sage grouse populations from much of their previous range (Klebenow 1985). In Oregon, sage grouse were once common to abundant in non-forested areas east of the Cascade Mountains (Gabrielson and Jewett 1940). Sage grouse declined in abundance and distribution during the early 1900s and occupied approximately one-half of their original range in Oregon by 1940 (Crawford and Lutz 1985). Analysis of trend data collected by the Oregon Department of Fish and Wildlife (ODFW) since 1940 indicated that populations had declined approximately 60% and productivity measures (chicks/adult and percent of adults with broods) had decreased nearly 80% (Crawford and Lutz 1985). Survival indices fluctuated but were unrelated to sage grouse declines; reduced productivity fully accounted for decreased sage grouse abundance since 1950 (Crawford and Lutz 1985).

Impaired productivity may result from a several factors, but productivity of sage grouse is largely a function of habitat characteristics available to hens for nesting and brood-rearing (Klebenow 1969, Blake 1970, Autenrieth 1981). The importance of big sagebrush for nesting habitat is well documented (Patterson 1952:114, Gill 1965, Gray 1967, Klebenow 1969, Wallestad and Pyrah 1974, Peterson 1980). In Montana, Wallestad and Pyrah (1974) reported depressed nesting success for hens with nests located in sagebrush stands of below average canopy cover. Further, litter and grass-forb understory contributed to successful nesting in Idaho (Autenrieth 1981) and

Utah (Rasmussen and Griner 1938) by providing additional camouflage at the nest site. Low availability of forbs resulted in decreased brood survival in Idaho (Blake 1970).

Several authors provided descriptions of sage grouse nesting habitat, selection of vegetative characteristics by hens, and relation of nest site characteristics to available habitat (Patterson 1950, Gray 1967, Wallestad and Pyrah 1974, Hulet et al. 1986). Sage grouse selected nest sites based largely on 2 vegetative components: height and percent cover of sagebrush (Klebenow 1969, Roberson 1986). Further, percent grass cover (Klebenow 1969) and grass height (Wakkinen 1990) also were related to selection of nest sites.

Previous authors also reported female sage grouse selected for specific habitat components for brood-rearing. In Idaho, Klebenow (1969) found height of sagebrush, density of canopy cover, and forb availability influenced brood site selection. In Colorado, Dunn and Braun (1986) found the amount of edge and horizontal and vertical cover of shrubs affected habitat selection by hens with broods. In Montana, Wallestad (1971, 1975) noted water and forb availability influenced brood habitat selection. Hens with broods in Nevada selected meadow habitat because of greater abundance of forbs (Oakleaf 1971, Evans 1986).

Little information, however, is available about habitat use in the portion of the range that encompasses the western subspecies (*C. u. phaios*). This subspecies was listed as a candidate for threatened and endangered status by the U.S. Department of the Interior (Federal Register, 18 September 1985) because of declines in Oregon and Washington, and extirpation from British Columbia. Further, relationships between habitat components, reproductive success, and current land-management practices are largely unknown. A better understanding of the relationship between habitat use and reproductive success

of sage grouse in Oregon is essential for enhancement of populations through sound land-management practices.

OBJECTIVES

Objectives of this project were:

1) to determine use and selection of cover types and habitat components by sage grouse hens during the breeding season in southeastern Oregon, and

2) to compare habitat use and selection between successful and unsuccessful hens for nesting and brood-rearing and to describe habitat use by broodless hens.

ACKNOWLEDGMENTS

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STUDY AREAS

The study was conducted on two areas (Figure 1): Hart Mountain National Antelope Refuge administered by the U.S. Fish and Wildlife Service (USFWS) and Jackass Creek administered by the Bureau of Land Management (BLM). Information about sage grouse populations, dating to the 1950s, was available from surveys conducted by ODFW at Jackass Creek and by the USFWS at Hart Mountain and from two previous research projects. Hart Mountain served as a location for study of habitat use and diet of sage grouse hens (Nelson 1955) and Jackass Creek was used by ODFW for an investigation of habitat selection for nesting and brooding by sage grouse from 1984 to 1986 (G. P. Keister, Oreg. Dep. Fish and Wildl., unpubl. data).

These areas were selected for comparison because of long-term differences in sage grouse abundance and productivity. Estimates of sage grouse density since 1980 was approximately 2.5 birds/km^2 and 1.5 bird/km^2 at Hart Mountain and Jackass Creek, respectively (J. C. Lemos, Oreg. Dep. Fish and Wildl., unpubl. data; W. H. Pyle, U.S. Fish and Wildl. Serv., unpubl. data). Density estimates were based on numbers of males/lek and a sex ratio of 40 males:60 females (Rogers 1964). Summer productivity counts from 1981 through 1990, the only period for which comparable data were available, were 1.9 (SE = 0.4) and 1.0 (SE = 0.2) chicks/hen for Hart Mountain and Jackass Creek, respectively.

Hart Mountain National Antelope Refuge

Hart Mountain National Antelope Refuge, located 70 km northeast of Lakeview in Lake County, Oregon comprised nearly 89,000 ha. Elevation ranged from 1,500 m at the eastern portion of the refuge to 2,450 m in the west (Warner peak). Hart Mountain and the surrounding shrub-steppe consisted of flat sagebrush plains interrupted by rolling hills, ridges, and draws.

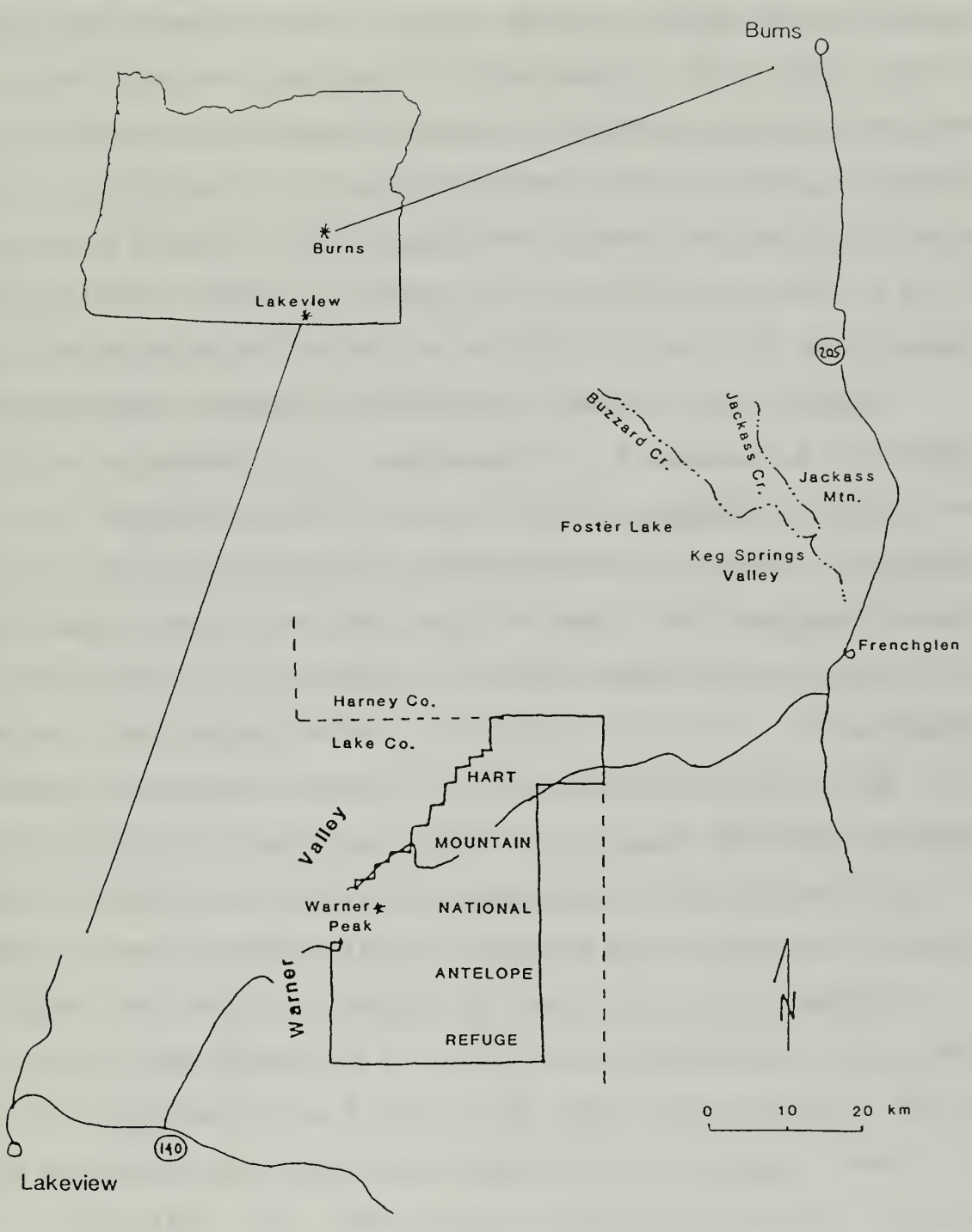

Figure 1. Location of the study areas in Lake and Harney Counties, Oregon.

Several springs, lakes, creeks, and meadow habitats were present on the area. Seasonally flooded lakebeds, some of which hold water throughout the summer, were most common in the southern portion of the study area. At refuge headquarters (elevation 1700 m), maximum temperature (March-September) averaged 21° C and annual mean precipitation was 29 cm (1939-1986). Precipitation (September through June) averaged 23 cm from 1989-91 (W. H. Pyle, U.S. Fish and Wildl. Serv., pers. commun.). At higher elevations mean temperature was lower and precipitation was greater than at headquarters.

Prominent cover consisted of low sagebrush (Artemisia arbuscula), big sagebrush (A. t. vaseyana, A. t. wyomingensis, A. t. tridentata), and bitterbrush (Purshia tridentata). Stands of western juniper (Juniperus occidentalis), curl-leaf mountain-mahogany (Cercocarpus ledifolius), and aspen (Populus tremuloides) were common at higher elevations. Common annual and perennial forbs included mountain-dandelion (Agoseris spp.), milk-vetch (Astragalus spp.), hawksbeard (Crepis spp.), lupine (Lupinus spp.), and phlox (Phlox spp.). Grasses consisted largely of bluegrass (Poa spp.), bluebunch wheatgrass (Agropyron spicatum), needlegrass (Stipa spp.), fescue (Festuca spp.), giant wildrye (Elymus cinereus), and bottlebrush squirreltail (Sitanion hystrix). Plant nomenclature was taken from Hitchcock and Cronquist (1987).

Livestock grazing at Hart Mountain averaged 0.13 animal unit months (AUMs)/ha and were allocated from 15 April to 15 December under a rest rotation, deferred grazing system (W. H. Pyle, U.S. Fish and Wildl. Serv., pers. commun.). Grazing pressure was adjusted annually in relation to range conditions. Grazing by livestock was terminated in 1991. Wild horses numbered 25 in spring 1988 (W. H. Pyle, U.S. Fish and Wildl. Serv., pers. commun.). In 1985, a rangefire burned approximately 4,500 ha in the center of the refuge.

Jackass Creek

The Jackass Creek study area, located approximately 100 km northeast of Hart Mountain in Harney County, Oregon, comprised nearly 39,000 ha and was topographically more uniform than Hart Mountain. The area consisted of flat sagebrush-covered plains in the west and undulating ridges and draws to the east, eventually rising to Jackass Mountain. The main plateau descended into Keg Springs Valley to the south and Jackass Creek canyon bisected the study area east to west. Buzzard Creek formed a second major drainage that joined Jackass Creek in the northeast and Foster Lake formed a large, seasonal lakebed at the western end of the study area. The main sources of water were Jackass Creek, Buzzard Creek, lakebeds, and water developments. Elevation ranged from 1,200 to 1,700 m. Maximum temperature (March-September) averaged 24° C and annual mean precipitation was 28.5 cm (1939-1986). Precipitation (September through June) averaged 24 cm from 1989-91 (W. F. Taylor, Bur. of Land Manage., pers. commun.).

Prominent vegetation consisted of low sagebrush and big sagebrush. Western junipers were present, but limited to the eastern portion of the study area. Meadow habitats were small and widely dispersed. Forbs and grasses were similar to those at Hart Mountain. Livestock grazing averaged 0.18 AUMs/ha under a deferred grazing system and use by wild horses averaged 0.05 AUMs/ha from 1985 through 1990 (W. F. Taylor, Bur. of Land Manage., pers. commun.) Livestock grazing was permitted from 1 April to 1 September. No livestock grazing was permitted in 1991 because of severe drought.

METHODS

Habitat selection by hens for nesting and brood-rearing, and by broodless hens in summer (June-August) was evaluated on the hierarchical order of selection suggested by Johnson (1980). Third order selection was defined

as selection for cover types and fourth order selection was defined as selection for habitat components within cover types. Fieldwork was conducted from summer 1988 through summer 1991.

Trapping and Radio-marking of Hens

Sage grouse were captured in summer 1988, spring and summer of 1989 and 90, and spring 1991. Rocket nets, net guns, and spotlighting were used to capture grouse (Giesen et al. 1982). Sex and age of grouse were determined by plumage characteristics and wing molt (Beck et. al. 1975). Each hen (adult or yearling only) was fitted with a numbered aluminum leg band and a poncho-mounted, solar-powered radio transmitter with a nickel-cadmium battery (Amstrup 1980). At the conclusion of each field season, marked hens were captured and radio transmitters removed. A sample of previously unmarked hens was fitted with radios to maintain an independent sample of nesting and brood-rearing habitats among years.

Monitoring Radio-marked Hens

Cover types and habitat components used for nesting, brood-rearing, and summer habitat were determined from locations of radio-marked hens. Marked hens were monitored beginning in April of each year to determine nesting chronology. Hens were relocated 3 times weekly with a hand-held antenna and portable receiver. When monitoring revealed that a hen initiated a nest, visual confirmation was made. Subsequently, radio locations were taken remotely (>100 m) to avoid disturbance. Hatch dates were estimated for all nests by projection from the onset of incubation. When monitoring revealed that a hen moved from a nest and incubation had ceased, the fate of the nest was determined. A nest was classified as successful if at least one egg hatched. Nests were determined unsuccessful if firmly attached shell membranes in broken eggs were found or eggs were missing. Nests were

considered depredated if destroyed by predators during incubation and nondepredated if at least 1 egg hatched or if incubation exceeded 30 days. Monitoring of unsuccessful hens was continued to assess renesting activities.

Radio-marked hens with broods were monitored 4 times weekly to determine habitats used for brood-rearing. Each visual location was marked and served as a site for habitat sampling. Monitoring of broods continued until the hen lost the brood or brood integrity disintegrated (approximately 1 August of each year). A hen was considered successful if she recruited at least one chick into the August population.

Radio-marked hens without broods were monitored at least once a month in summer (June-August). Visual locations of radio-marked broodless hens were marked and served as a site for habitat sampling during summer 1990. Date, location, and flock size of broodless hens and hens with broods observed on each study area throughout summer were recorded in field notebooks. Definitions of monthly time periods were early (first 10 days), mid (middle 10 days), and late (last 10 days). Brood routes were conducted daily from 4 hours before sunset at both study areas from 15 June to 15 July during each field season.

Selection of Cover Types

Eleven cover types were described from Soil Conservation Service information (J. Kinzle, U.S. Dep. Agric., Soil Conserv. Serv., unpubl. data) and previous descriptions at Jackass Creek by Trainer et al. (1983) (Table 1). Cover types were defined on the basis of dominant shrubs and grasses. Boundaries of the 11 cover types were determined from color infrared aerial photographs and overlayed on topographic maps of each study area with zoom transfer scopes. Interpretation and ground verification of cover type maps

Table 1. Description of cover types at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, Oregon.

Cover type	Cover type description
Low sagebrush/bunchgrass	Found on alluvial fans and table lands with <30% slope. Principal plant species are low sagebrush (Artemisia arbuscula), bluebunch wheatgrass (Agropyron spicatum), and bluegrass (Poa spp.). Also may be associated with spiny hopsage (Atriplex spinosa).
Low sagebrush/fescue	Found on exposed ridges and side slopes at higher elevations (2000 to 2800m) at Hart Mountain. Primary plant species are low sagebrush and Idaho fescue (Festuca idahoensis).
Wyoming big sagebrush	Occurs on rolling uplands and lake basin terraces with slopes <30%. Primary plant species include Wyoming big sagebrush (A. tridentata wyomingensis) and bottlebrush squirreltail (Sitanion hystrix). Also may be associated with spiny hopsage.
Mountain big sagebrush	Occurs at higher elevations (1800 to 2600m) on ridges and mountain shoulders. Primary plant species are mountain big sagebrush (A. t. vaseyana) and Idaho fescue or rough fescue (F. scabrella).
Mixed sagebrush	Characteristic of scabrock areas (15 to 75% rock fragments) associated with ridge tops, sloping tablelands, and alluvial planes. Primary plant species are low sagebrush, big sagebrush, and Sandberg's bluegrass (P. sandbergii).
Mountain shrub	Common at Hart Mountain at elevations between 1800 and 2300m. Primary plant species are mountain big sagebrush, bitter-brush (Purshia tridentata), blue grass, and needlegrass (Stipa spp.).
Basin big sagebrush	Occurs on low terraces associated with drainages and lake basins. Primary plant species are basin big sagebrush (A. t. tridentata) and giant wild rye (Elymus cinereus).

Table 1. (continued)

Cover type	Cover type description
Grassland	Natural grasslands or areas disturbed by fire. Primary plant species are cheat grass (Bromus tectorum), bluegrass, and bottlebrush squirreltail.
Meadow	Associated with stream valleys that have poorly drained soils and subsurface water in summer. Primary plant species are bluegrass, sedge (Carex spp.), and baltic rush (Juncus balticus).
Lakebed	Found on depressions covered with water in spring. Primary plant species are silver sagebrush (A. cana) and bluegrass.
Juniper/aspen/mahogany	Associated with low ridges or footslopes. Primary plant species are western juniper (Juniperus occidentalis), aspen (Populus tremuloides), and curl-leaf mountain-mahogany (Cercocarpus lepifolius). May be found interspersed with big sagebrush.

were conducted throughout each field season. Two of the 11 cover types were not present at Jackass Creek (mountain shrub and low sagebrush/fescue). Each radio-marked hen location was classified into 1 of the 11 cover types. Boundaries of the area available for nesting, brood-rearing, and summer habitat on each study area were determined from locations of radio-marked hens with the minimum convex polygon method (Odum and Kuenzler 1955). Available nesting habitat included all area within the boundaries of the outermost nesting hens; only locations of hens exhibiting nesting behavior (reduced localized movements) were used. Available brood-rearing habitat included the composite home ranges of all hens with broods (Whiteside and Guthery 1983). Available summer habitat included all area within the locations of hens in June through August. Proportion of each cover type within the available habitat boundaries were determined with a dot grid system (Avery 1977).

Selection of Habitat Components

Habitat components were measured in a 78-m^2 area (circular area with a radius of 5 m) at all nest and brood locations in 1989-91 and at broodless hen locations in 1990. Habitat components were measured after hatching for successful nests and on predicted hatch dates for unsuccessful nests from May through mid-June of each field season. Brood and broodless hen sites were measured within 2 days after the location was determined. Brood and broodless hen habitat data were collected from May through August and June through August, respectively.

Within each cover type, habitat components were also measured in a 78-m^2 at randomly selected locations in May and July to characterize available nesting, brood-rearing, and summer habitats. A starting point for each random site was located on a cover type map with a random numbers table. Once at the

starting point, the distance and direction of travel to the center of the transect was determined with a random numbers table. The number of random locations sampled in each cover type was based on canopy cover of sagebrush and was determined with an "n-test" (Snedecor and Cochran 1980:221).

Canopy cover (%) of shrubs, forbs, and grasses; height classes of shrubs; frequency of herbaceous vegetation; and vertical cover were measured at all nest, brood, broodless hen, and random sites. Canopy cover of shrubs was measured by line intercept (Canfield 1941) along 2 10-m perpendicular transects intersecting at the center of the use site or random location. The position of the first transect was determined from a randomly selected compass bearing. Height of each shrub intercepted was measured from the ground to the top of the shrub canopy and placed into 1 of 3 classes: short (<40 cm), medium (40-80 cm), or tall (>80 cm). Canopy cover of shrubs was recorded separately for each height class. Shrubs were identified to species and forbs and grasses were identified to genus. Dominant forb and grass genera were defined as those with percent cover $\geq$1 or frequency $\geq$25 (Appendices A, B, C, and D).

Cover of forb and grass genera was estimated in 5 20 x 50-cm rectangular plots equidistantly spaced on each transect (Daubenmire 1959). Sampling intensity was determined by constructing a species area curve with data collected from initial vegetation sampling (Pieper 1978:12). Tallest droop height (excluding flower stalks) of grasses were measured at the nest bush and at random locations throughout each study area during May. Wakkinen (1990) reported grass height of 18 cm at sage grouse nests in Idaho. Therefore, grass genera < 18 cm were classified as short and > 18 cm were classified as tall.

Cover at the center of the transect was determined with a 1 x 1-m cover board. Measurements were taken from a distance of 1.5 m at 45° and 5 m at a height of 50 cm (Jones 1968, Dunn and Braun 1986). Preliminary evaluation of

the data revealed that the two cover-board measurements were intercorrelated with other vegetative measures; consequently, cover-board data were not used in habitat analyses.

CHAPTER ONE

TRAPPING AND REPRODUCTIVE SUCCESS

RESULTS

Two-hundred-seventy-eight sage grouse hens were captured and marked with radio transmitters (139 at each study area) during 3 field seasons (Table 2). Hens were captured by spotlighting (86%) and with rocket nets (10%) and net guns (4%). Rocket nets were only used during summer 1988. Adult hens comprised 74%, 84%, and 93% of the radio-marked hens in 1989, 1990, and 1991, respectively. Breeding information was obtained from 162 radio-marked hens (84 at Hart Mountain and 78 at Jackass Creek) that were alive and functional radios at the beginning of each field season (March). The remaining 116 radio-marked birds were excluded from the analysis. Prior to the breeding season 49 died (during summer, fall, or winter) and 50 were missing or had radio failure. Seventeen hens 17 were located off the study areas and no breeding information was obtained (Table 3).

During the 3 breeding seasons, 73% (118/162) of the radio-marked hens nested (initiated incubation). Forty-four (27%) hens either did not attempt to nest or nests were depredated during egg laying. Frequency of nest initiation declined at both areas from 1989 through 1991, but overall, was greater ($X^2 = 4.04$, $df = 1$, $P < 0.05$) at Jackass Creek (81%) than at Hart Mountain (65%) (Table 4). Twelve hens renested after an unsuccessful initial attempt during 3 breeding seasons (Table 4). Renesting rate among years was similar at Hart Mountain, but was greater at Jackass Creek in 1991. Nest success declined at both areas from 1989 to 1991 (Table 4). Nest success was 20% at Hart Mountain and 11% at Jackass Creek and overall was 15% across study areas. Predation was the primary cause of nest failure (107/112, 96%). Ravens (Corvus corax), coyotes (Canis latrans), badgers (Taxidea taxus) and

Table 2. Capture techniques used and age of female sage grouse captured and marked with radio transmitters at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, Oregon, 1989-91.

	Spotlight		Net Gun		Rocket Net		
	Yrlg.[a]	Ad.	Yrlg.	Ad.	Yrlg.	Ad.	Total
1989 FIELD SEASON -- Summer 1988							
Hart Mt.	5	1	2	2	13	1	24
Jackass Cr.	5	1	-	1	11	3	21
Spring 1989							
Hart Mt.	12	6	-	2	Not used		20
Jackass Cr.	9	7	-	-			16
1990 FIELD SEASON -- Summer 1989							
Hart Mt.	5	6	4	1	Not used		16
Jackass Cr.	12	24	-	-			36
Spring 1990							
Hart Mt.	10	27	Not used		Not used		37
Jackass Cr.	7	10	-	-			17
1991 FIELD SEASON -- Summer 1990							
Hart Mt.	7	16	Not used		Not used		23
Jackass Cr.	12	21					33
Spring 1991							
Hart Mt.	3	16	Not used		Not used		19
Jackass Cr.	3	13	-	-			16
TOTALS							
Hart Mt.	42	72	6	5	13	1	139
Jackass Cr.	48	76	0	1	11	3	139

[a] Yearlings captured during summer were classified adults by the following breeding season.

Table 3. Status of radio-marked sage grouse hens at Hart Mountain National Antelope Refuge (HM) and Jackass Creek (JC) study areas, Lake and Harney counties, Oregon, 1989-91.

	1989		1990		1991		
Status	HM	JC	HM	JC	HM	JC	Total
Alive	21	23	39	34	24	21	162
Mortality	11	2	9	11	8	8	49
Missing	6	12	1	6	11	14	50
Unknown[a]	6	0	4	0	0	7	17
Total	44	37	53	51	43	50	278

[a] Birds located off study areas and no breeding information was obtained.

Table 4. Reproductive success (%) of radio-marked sage grouse hens at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, Oregon, 1989-91.

Measure	1989	1990	1991	Total
HART MOUNTAIN				
Nest Initiation	71 (15/21)[a]	74 (29/39)	46 (11/24)	65 (55/84)
Renesting Rate	10 (1/10)	18 (4/22)	9 (1/11)	14 (6/43)
Nest Success	33 (5/15)	21 (6/29)	0 (0/11)	20 (11/55)
Brood Success	60 (3/5)	17 (1/6)	0 (0/0)	36 (4/11)
Broods/Hen[b]	14 (3/21)	2 (1/39)	0 (0/24)	5 (4/84)
JACKASS CREEK				
Nest Initiation	87 (20/23)	85 (29/34)	67 (14/21)	81 (63/78)
Renesting Rate	6 (1/16)	4 (1/27)	31 (4/13)	11 (6/56)
Nest Success	20 (4/20)	7 (2/29)	7 (1/14)	11 (7/63)
Brood Success	25 (1/4)	50 (1/2)	100 (1/1)	43 (3/7)
Broods/Hen	4 (1/23)	3 (1/34)	5 (1/21)	4 (3/78)

[a] % (n/total n)

[b] On 1 August.

ground squirrels (Citellus spp.) were implicated in nest losses. Four nests were abandoned (2 at Hart Mountain and 2 at Jackass Creek). One hen incubated for 44 days without hatching.

Eleven broods were hatched at Hart Mountain and 7 were hatched at Jackass Creek (Table 4). Four hens recruited broods (6 chicks) into the August population at Hart Mountain and 3 hens recruited broods (3 chicks) at Jackass Creek. Productivity of radio-marked and unmarked sage grouse was low at both areas and declined from 1989 to 1991 (Table 5). Proportion of hens with broods was similar between radio-marked hens and unmarked hens at Hart Mountain ($X^2 = 0.23$, df = 1, $P > 0.05$) and at Jackass Creek ($X^2 = 1.16$, df = 1, $P > 0.05$).

DISCUSSION

Nest success of radio-marked hens observed in this study was less than previous sage grouse studies conducted in Oregon. Nelson (1955) reported 39% nest success at Hart Mountain and Drakes Flat in Lake County. Batterson and Morse (1948) reported 24% nest success in Baker County. Sage grouse studies in other states revealed nesting success ranged from 25% (Patterson 1952:104) to 64% (Wallestad and Pyrah 1974). In 12 studies, with a total of 699 nests, overall success was 35% (Bergerud 1988:593). Nest success from most sage grouse studies were estimated from nest searches, which perhaps were biased because only the most conspicuous nests were found (Bergerud 1988). Previous authors reported nest success of radio-marked sage grouse of 40% (Peterson 1980), 61% (Wakkinen 1990), and 64% (Wallestad and Pyrah 1974). Low productivity exhibited by both marked and unmarked hens observed in this study suggested that radio transmitters had little influence on nesting success of radio-marked hens. Further, the increase of adult females captured from 1989

Table 5. Summary of productivity data obtained from sage grouse brood routes and radio-marked hens at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, Oregon, 1989-91.

Location	Hens	Chicks	Hens w/ Broods	Hens w/o Broods	Chicks/ Hen	% Hen w/ Broods	Chicks/ Brood
			HART MOUNTAIN				
Hart Mt.	35[a]	23	10	25	0.7	29	2.3
(USFWS/OSU)	102[b]	46	16	86	0.5	16	2.9
	48[c]	9	4	44	0.3	8	2.3
Radio-marked	21	--	5	16	--	24	--
Hens	39	--	6	33	--	15	--
	24	--	0	24	--	0	--
			JACKASS CREEK				
Jackass Cr.	107	61	16	91	0.6	15	3.8
(ODFW)	54	23	8	46	0.4	15	2.9
	7	2	1	6	0.3	14	2.0
Jackass Cr.	112	77	20	92	0.7	18	3.8
(OSU)	130	65	20	110	0.5	15	3.3
	0	0	--	--	--	--	--
Radio-marked	23	--	4	19	--	17	--
Hens	34	--	2	32	--	6	--
	21	--	1	20	--	5	--

[a] 1989 data.
[b] 1990 data.
[c] 1991 data.

to 1991 was reflective of reduced productivity observed at both study areas for unmarked hens during the same time period.

The decline in numbers of nests initiated each year and differences between study areas may be related to nutritional condition of hens during the pre-laying period (March-April). Nutrition before and during the breeding season may have a significant effect on reproduction of galliformes (Beckerton and Middleton 1982, 1983). An abundance of herbaceous forbs in March may be important for increasing metabolic reserves before nesting and providing protein for reproductive needs (Servello and Kirkpatrick 1988). This study was conducted during a drought and in years of below average precipitation forb availability may be reduced (Blake 1970). A study investigating diet and nutrition of pre-laying sage grouse was initiated at Hart Mountain and Jackass Creek in 1990.

CHAPTER TWO

USE AND SELECTION OF NESTING HABITAT

Predation ia a major factor affecting nesting success of birds (Ricklefs 1969). Batterson and Morse (1948) and Nelson (1955) identified predation as the primary factor directly influencing sage grouse nesting success in Oregon. Although, predators may act as the proximate agent of nest loss, the ultimate cause may relate to habitat inadequacies. For example, ground nests located in areas with more cover or greater vegetative structural diversity were less likely to be depredated than nests located in areas with little cover or simple structure (Bowman and Harris 1980, Redmond et al. 1982). We hypothesized that predation of sage grouse in Oregon was related to cover types used for nesting or to vegetative structural components surrounding nests. Our objectives were to determine cover types used for nesting in relation to availability of cover types, to identify vegetative characteristics of nest sites in comparison with random sites, and to compare vegetative characteristics of nondepredated and depredated sage grouse nests at the 2 study areas.

DATA ANALYSIS

Relative proportions of cover types used for nesting were compared with availability of cover types within study areas and cover type use was compared between study areas with Chi-square analysis. If differences were detected, confidence intervals were calculated to identify cover types that contributed to the difference (Neu et al. 1974, Byers et al. 1984). Number of nests depredated were compared among cover types used for nesting with Chi-square analysis.

To determine the scale of selection of vegetative features by sage grouse, the 78-m^2 area in which vegetative measurements were taken was

apportioned into 2 components: 1) the nest, which encompassed a 3-m^2 area at the nest and 2) the nest area, which encompassed the surrounding 75-m^2 area (Figure 2). Comparisons were made between the nest, nest area, and random sites and between nondepredated and depredated nests. Further, vegetative components of all nests at Hart Mountain were compared with all nests at Jackass Creek. Multivariate analysis of variance (MANOVA) was used for these tests. If a significant MANOVA was found, a factorial analysis of variance (ANOVA) was used to determine habitat components that contributed to the difference (Snedecor and Cochran 1980:339). Factors in the ANOVA models were plot type (nest or random site), status (nondepredated or depredated nest), study area, cover type, and year. The least significant difference test was used to separate means. Assumption of normality was met and no transformations of the data were required. Results were considered significant at the 95% confidence level.

RESULTS

Information was collected on 130 nests (61 at Hart Mountain and 69 at Jackass Creek): 19, 107, and 4 nests were nondepredated, depredated and abandoned, respectively. Nest site characteristics were not measured at 1 nondepredated and 1 depredated nest at Hart Mountain. Study area sizes (available nesting habitat) were similar for each area, 948 km^2 and 943 km^2 at Hart Mountain and Jackass Creek, respectively.

Sage grouse nested in 7 of 11 cover types at Hart Mountain. Mountain big sagebrush was used more frequently and low sagebrush/bunchgrass and Wyoming big sagebrush used less frequently than available (Table 6). At Jackass Creek, sage grouse nested in 4 of 9 cover types. Mixed sagebrush (mosaic of low and big sagebrush) was used more frequently than expected based on availability (Table 6). All other cover types were used in proportion to

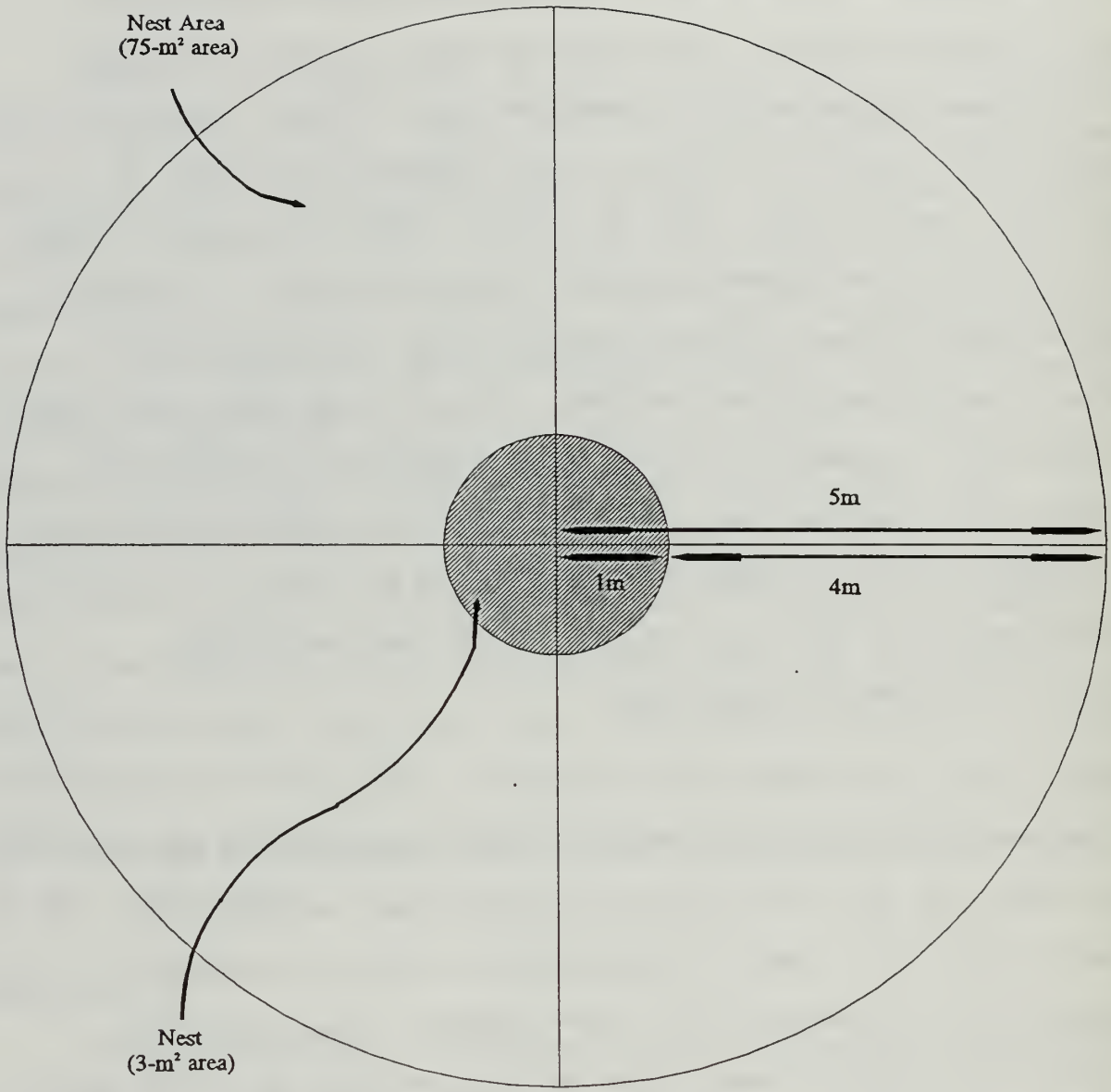

Figure 2. The 78-m^2 area on which vegetative features were measured at sage grouse nests were apportioned into 2 components for purposes of data analysis. The Nest represented the 3-m^2 area surrounding the nest bush. The Nest Area represented the 75-m2 area surrounding the Nest.

Table 6. Cover types, cover types available, and percent of nests in cover types used by radio-marked sage grouse hens at Hart Mountain National Antelope Refuge (n = 61) and Jackass Creek (n = 69), Lake and Harney counties, Oregon, 1989-91.

Cover type	Hart Mountain		Jackass Creek	
	% Available	% of Nests	% Available	% of Nests
Low sagebrush/bunchgrass	40	20[a]	29	32
Wyoming big sagebrush[b]	26	7[a]	53	35
Mountain big sagebrush[b]	13	57[c]	2	0
Grassland	6	2	1	0
Juniper/aspen/mahogany	5	0	1	0
Mountain shrub	3	10	0	0
Low sagebrush/fescue	2	3	0	0
Lakebed	2	0	5	0
Meadow	2	0	<1	0
Basin big sagebrush	1	2	2	1
Mixed sagebrush[b]	<1	0	7	32[c]

[a] Use less than expected ($P < 0.05$).
[b] Use different between study areas ($P < 0.05$).
[c] Use greater than expected ($P < 0.05$).

their availability. Sage grouse used Wyoming big sagebrush and mixed sagebrush more frequently and mountain big sagebrush less frequently at Jackass Creek than at Hart Mountain (Table 6).

A greater percentage of nests were nondepredated in mountain big sagebrush stands than in any other cover type ($X^2 = 6.56$, $P < 0.05$). Mountain big sagebrush at Hart Mountain contained 27% of all nests and 30% (10/33) were nondepredated. Only 9% (9/93) of the remaining nests in 7 other cover types at both study areas were nondepredated.

Approximately 95% (123/130) of nests from radio-marked hens were located under sagebrush. Other vegetation used for nesting included rabbitbrush (Chrysothamnus spp.) (n = 5), bitter-brush (n = 1), and giant wildrye (n = 1). Sagebrush collectively represented 87% of the shrub component at both study areas. Other shrubs included bitter-brush (6%), rabbitbrush (4%), horsebrush (Tetradymia spp.) (1%), and snowberry (Symphoricarpos oreophilus) (1%). Tall grass genera included giant wildrye, bluebunch wheatgrass, fescue, and needlegrass. Short grass genera consisted of bottlebrush squirreltail, junegrass (Koeleria cristata), brome (Bromus spp.), and bluegrass (Table 7, Appendix E).

Shrub cover of medium height (40-80 cm) was greater at nests than in the area immediately surrounding nests or at random locations (Table 8). Shrub cover of short height was greater at nests than at random locations only in low sagebrush cover types. Cover of tall grass genera (>18 cm) was greater and short grass genera less at nests than in the immediate area around nests or at random locations.

Nondepredated nests had greater cover of tall grass genera and medium height shrub cover than depredated nests (Table 9). However, a significant cover type interaction was detected for mountain big sagebrush stands, where cover of tall grass genera was greater at nondepredated nests ($\bar{x} = 27$, SD =

Table 7. Height (cm) of dominant grass genera at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, Oregon.

Genus	$\bar{x}$	SD	n
Elymus	53	12	39
Agropyron	28	6	62
Festuca	20	6	78
Stipa	18	5	122
Sitanion	15	5	122
Koleria	14	3	62
Bromus	11	4	36
Poa	6	4	106

Table 8. Habitat characteristics (% cover) at nests (3-m^2 area at nests) and nest areas (75-m^2 area surrounding nests) of radio-marked sage grouse hens and random locations at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1989-91.

	Nest (n = 128)		Nest area (n = 128)		Random (n = 499)	
Characteristic	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Grass cover						
Short, < 18 cm	6	6A[a]	8	5B	8	7B
Tall, > 18 cm	7	15A	4	6B	3	5B
Forb cover	9	9A	9	6A	9	6A
Shrub cover						
Short, < 40 cm	18	20A[b]	16	11AB	14	10B
Medium, 40-80 cm	31	22A	11	11B	8	10C
Tall, > 80 cm	3	11A	1	3B	3	6A

[a] Means followed by the same letter within a row are not different ($P > 0.05$).

[b] Differences in short shrub cover were found only in low sagebush cover types.

Table 9. Habitat characteristics (%) at undepredated and depredated nests (3-m^2 at nests) of radio-marked sage grouse hens at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1989-91.

	Undepredated (n = 18)		Depredated (n = 106)	
Characteristic	$\bar{x}$	SD	$\bar{x}$	SD
Grass cover				
Short, < 18 cm	6	5A[a]	6	7A
Tall, > 18 cm	18	24A	5	12B
Forb cover	8	5A	9	9A
Shrub cover				
Short, < 40 cm	14	17A	19	20A
Medium, 40-80 cm	41	22A[b]	29	22B
Tall, > 80 cm	1	3A	4	12A

[a] Means followed by the same letter within a row are not different ($P > 0.05$).

[b] Signficant cover type interaction was detected. Medium height shrub cover was not different in mountain big sagebrush stands.

25, n = 10) than at depredated nests ($\bar{x}$ = 3, SD = 6, n = 23) and no differences in medium height shrub cover ($\bar{x}$ = 44, SD = 24 and $\bar{x}$ = 39, SD = 17 at nondepredated and depredated nests, respectively) were detected. In all cases but one, tall grasses at undepredated nests were composed of residual cover. In the exceptional case, grass cover at the nest was provided from growth of the current year.

Nests at Hart Mountain had greater cover of tall grass genera and less cover of short grass genera and tall shrubs than nests at Jackass Creek (Table 10). At Jackass Creek, nests had more forb cover and greater cover of tall shrubs than nests at Hart Mountain (Table 10). Availability of tall grass cover was greater at Hart Mountain ($\bar{x}$ = 4, SD= 6, n = 287) than at Jackass Creek ($\bar{x}$ = 1, SD= 3, n = 212).

DISCUSSION

Results of this study indicated that nesting sage grouse selected cover types (mixed sagebrush and mountain big sagebrush) with a medium height (40-80 cm) shrub component and areas with greater cover of tall residual grasses (>18 cm) for nesting. Further, amount of tall residual grass cover and medium height shrub cover were the only habitat components measured that differentiated nondepredated and depredated nests. These findings suggest there is a relationship between habitat structural characteristics and depredation of nests.

The importance of grass cover at sage grouse nests has been suggested by other authors, but has not been well documented by previous studies. Wakkinen (1990) suggested grass height was a possible factor in determination of nest fate. Pyrah (1971) noted more grass cover at successful nests (43%, n=9) than at unsuccessful nests (33%, n=4), but sample sizes were small and no statistical comparisons were made. Rasmussen and Griner (1938) found lower

Table 10. Habitat characteristics (%) at nests (3-m^2 at nests) of radio-marked sage grouse hens at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1989-91.

	Hart Mountain (n = 59)		Jackass Creek (n = 69)	
Characteristic	$\bar{x}$	SD	$\bar{x}$	SD
Grass cover				
Short, < 18 cm	4	4A[a]	7	8B
Tall, > 18 cm	12	19A	2	7B
Forb cover	7	6A	10	10B
Shrub cover				
Short, < 40 cm	17	17A	20	22A
Medium, 40-80 cm	34	21A	29	23A
Tall, > 80 cm	1	3A	5	15B

[a] Means followed by the same letter within a row are not different ($P > 0.05$).

nest success in sagebrush stands without a herbaceous understory than in stands with a herbaceous understory. Similarly, Autenrieth (1981:20) suggested a herbaceous understory contributed to successful nesting. Our data clearly indicate the importance of grass cover at sage grouse nests. Greater amounts of tall residual grass at nests likely provided increased nest concealment from predators and were less likely to be depredated than nests with less tall residual grass.

The importance of big sagebrush for nesting is well documented in the literature. Wallestad and Pyrah (1974) reported successful nests were in sagebrush stands with greater canopy cover than unsuccessful nests and had greater sagebrush cover within 60 cm of the nest and a 9-m^2 plot around the nest. In Utah, Rasmussen and Griner (1938) found highest nest densities and nest success in a big sagebrush cover type with sagebrush of medium height (> 50% canopy cover and sagebrush > 46 cm tall). Connelly et al. (1991) reported greater nest success for grouse nesting under sagebrush than for birds nesting under other plants.

Although big sagebrush is an essential component of sage grouse nesting habitat, our results indicate predation of sage grouse nests may be most directly associated with the amount of tall residual grass cover at nests. For grouse nesting in mountain big sagebrush at Hart Mountain, amount of tall residual grass cover was the only habitat component measured that differentiated nondepredated and depredated nests. The greater percentage of nondepredated nests in mountain big sagebrush stands was attributed to greater availability of tall residual grasses in this cover type.

At Jackass Creek, nondepredated nests also had greater cover of tall residual grasses than depredated nests. Further, depredated nests in mountain big sagebrush stands had only 3% cover of tall residual grasses, which was similar to depredated nests in other cover types (5% cover of tall residual

grasses). Collectively, these findings suggest that the relationship between habitat components and predation of sage grouse nests was a structural relationship and not a plant community (cover type) relationship.

Differences in productivity, and ultimately in abundance of sage grouse between study areas may be related to differences in availability of tall residual grasses. Medium sagebrush cover was not limited in either study area; however, cover of tall grasses at nests and random locations was greater at Hart Mountain than at Jackass Creek. Differences in amount of tall grass cover between study areas may be associated with differences in fire history, precipitation patterns, biotic potential, and land use practices such as grazing by domestic livestock. Grazing pressure was greater at Jackass Creek (0.23 AUMs/ha) than at Hart Mountain (0.13 AUMs/ha).

Selection of shrubs by hens in this study paralleled results of previous work. Past research, conducted in several states, revealed a large variation in canopy cover and shrub heights used by sage grouse for nesting, but within an area, hens selected nest sites based on height and percent cover of sagebrush (Roberson 1986). Previous authors reported stands used for nesting ranged from 20% to 44% shrub cover (Klebenow 1969, Wallestad 1975:30, Autenrieth 1981:19, Schoenberg 1982). Further, canopy cover was greater in the immediate area surrounding nests than at random sites (Klebenow 1969, Schoenberg 1982). Braun et al. (1977), in a review of sage grouse literature, noted height of sagebrush used for nesting ranged from 17 to 79 cm, but most nests were located under the tallest shrubs available at a site. Areas of big sagebrush taller than 90 cm were seldom used (Autenrieth 1981:17).

Regardless of cover type used for nesting, nests (3-m^2) had greater cover of medium height shrubs and tall residual grasses than the area immediately surrounding nests or random locations. This result indicated nest site selection was based on a relatively small area.

CHAPTER THREE

HABITAT USE AND SELECTION BY HENS WITH BROODS

Habitat availability and condition were factors that limited sage grouse populations and caused impaired productivity of sage grouse hens (Klebenow 1969, Blake 1970, Wallestad 1975, Martin 1976, Autenrieth 1981). Stand structure and forb availability were characteristics most associated with habitat selection by hens with broods (Klebenow 1969, Peterson 1970, Wallestad 1971, Autenrieth 1981, Dunn and Braun 1986). Forbs and insects formed the primary forage of sage grouse chicks and shrubs provided escape and thermal cover (Klebenow and Gray 1968, Peterson 1970). Consequently, a relationship may exist between availability of forage and escape cover and recruitment of broods into fall populations. We hypothesized that hens with broods selected cover types and habitat components within cover types and that selection was related to food availability and dietary requirements of chicks. Our objectives were to identify cover types used by sage grouse hens with broods in relation to availability, to identify habitat components at brood sites compared with random sites, and to identify the relationship between habitat use, diets of sage grouse chicks, and food availability in selected habitats on the 2 study areas.

DATA ANALYSIS

Analyses of cover types and habitat components were conducted for 2 brood-rearing periods; early (hatching to 6 weeks) and late (7 to 12 weeks after hatching). Six-week intervals were based on results from Martin (1970), which indicated hens with broods changed habitat use at this time, and information from Peterson (1970), who found a change in foods eaten by juveniles at approximately 6 weeks after hatching.

Minimum convex polygon home ranges were determined for hens with broods during each brood-rearing period with the McPaal home range program (Stuwe and Blohowiak 1983). Small sample sizes precluded home range analysis within and between study areas.

Cover types used by sage grouse for brood-rearing were compared with availability of cover types, both within and between study areas. Cover types used by hens with broods during the early brood-rearing period were compared to cover types used by hens that nested successfully. Furthermore, use of cover types by hens with broods was compared between brood-rearing periods to assess possible changes in habitat use associated with age of broods. Cover types with less than 5 observations were combined and analyzed collectively. For all tests, data were arranged in contingency tables and analyzed with Chi-square analysis. If differences were detected, confidence interval testing (Neu et al. 1974, Byers et al. 1984) was used to determine cover types associated with the difference.

Diets of juvenile sage grouse were obtained as part of a concurrent study (M. S. Drut, Oreg. State Univ., unpubl. data; W. H. Pyle, U. S. Fish and Wildl. Serv., unpubl. data) and comprised sagebrush, forbs, and arthropods. Key foods were defined by aggregate mass ($\geq$1%) or frequency ($\geq$10%) in crops of collected chicks. Key forbs common to both study areas included mountain-dandelion (Agoseris spp.), milk-vetch (Astragalus spp.), hawksbeard (Crepis spp.), daisy (Erigeron spp.), desert-parsley (Lomatium spp.), pink microsteris (Microsteris gracilis), broomrape (Orobanche spp.), common dandelion (Taraxacum officinale), and clover (Trifolium spp.). Additional key forbs identified included blepharipappus (Blepharipappus scaber) and dwarf woolly-heads (Psilocarphus brevissimus) at Jackass Creek and yarrow (Achillea spp.), aster (Aster spp.), monkey-flower (Mimulus spp.), and yellow salsify (Tragopogon dubius) at Hart Mountain. Key arthropods were identified as June

beetles (Scarabaeidae), darkling beetles (Tenebrionidae), and ants (Formicidae).

Within each study area, habitat components (% cover of shrubs, key forbs, all forbs, and grasses) measured at random locations were compared between cover types selectively used (used greater than available), proportionally used (used in proportion to availability), used less than available, and unused by hens with broods to determine vegetative features associated with use of cover types. To identify habitat components used selectively, comparisons were made between brood sites and random sites within each cover type used for brood-rearing at both study areas. Further, brood sites and random sites were compared between study areas to assess differences in use and availability of habitat components. Multivariate analysis of variance (MANOVA) was used for all comparisons. If a significant MANOVA was found, a factorial analysis of variance (ANOVA) was used to determine habitat components that contributed to the difference (Snedecor and Cochran 1980:339). Key forbs were analyzed separately with ANOVA. The Least Significant Difference test was used to separate means (Snedecor and Cochran 1980:272). Results were considered significant at the 95% confidence level.

RESULTS

Data were collected for 18 broods (11 at Hart Mountain and 7 at Jackass Creek) during the early brood-rearing period and 7 broods (4 at Hart Mountain and 3 at Jackass Creek) during the late brood-rearing period. At Hart Mountain, mean home range size was 8.2 km^2 and 1.4 km^2 for the early and late brood periods, respectively, whereas at Jackass Creek, mean home range size was 20.7 km^2 and 50.5 km^2, respectively (Table 11). Home range size was smaller in the late brood period than the early brood period at Hart Mountain; however, home range size increased during the late brood period at Jackass

Table 11. Home range, number of observations, and weeks observed for radio-marked hens with broods during each brood period at Hart Mountain and Jackass Creek study areas, Lake and Harney counties, Oregon, 1989-1991.

		Early			Late		
Year	Brood	Home range (km^2)	Observations	Weeks observed	Home range (km^2)	Observations	Weeks observed
				Hart Mountain			
1989	1	84.1	5	6	1.1	18	6
	2	1.0	22	6	1.3	12	4
	3	0.3	11	3	--	--	--
	4	0.2	4	1	--	--	--
	5	0.01	5	2	--	--	--
1990	6	1.4	17	6	1.9	10	4
	7	0.01	3	1	--	--	--
	8	0.2	3	1	--	--	--
	9	0.1	3	1	--	--	--
	10	1.3	6	2	--	--	--
	11	1.1	11	3	--	--	--
$\bar{x}$		8.2			1.4		
				Jackass Creek			
1989	1	90.4	21	6	16.3	27	6
	2	0.9	11	3	--	--	--
	3	0.2	12	3	--	--	--
	4	0.2	7	2	--	--	--
1990	5	31.5	20	6	84.7	12	4
	6	0.8	8	2	--	--	
$\bar{x}$		20.7			50.7		

Creek. Home range size was smaller at Hart Mountain than at Jackass Creek during both brood-rearing periods (Table 11)

At both study areas, most successful nests were located in big sagebrush cover types (Table 12). However, after hatching, hens with broods moved to low sagebrush cover types. Use of low sagebrush cover types was greater and use of big sagebrush cover types was less by hens with broods than by successfully nesting hens (Table 12). During the early brood-rearing period, hens with broods used low sagebrush/bunchgrass and mixed sagebrush at Jackass Creek and low sagebrush/fescue at Hart Mountain more frequently than expected (Table 13). Mountain big sagebrush was used in proportion to availability at Hart Mountain. Hens with broods used low sagebrush/bunchgrass at Hart Mountain and Wyoming big sagebrush at both study areas less frequently than expected (Table 13).

During the late brood-rearing period, hens with broods shifted use back to big sagebrush cover types on both study areas. Mountain big sagebrush at Hart Mountain and Wyoming big sagebrush at Jackass Creek were used greater during the late brood period than during the early brood period (Table 13). However, neither cover type was used in greater proportions than available. At Hart Mountain, hens with broods continued to use low sagebrush/fescue more frequently than expected. At Jackass Creek, no cover types were used selectively and low sagebrush/bunchgrass was used less than expected during the late brood-rearing period (Table 13). Further, use of riparian cover types (lakebeds at Jackass Creek and meadows at Hart Mountain) were observed at both study areas.

Availability of cover types differed between study areas for both brood-rearing periods (Table 13). During the early period, low sagebrush/fescue and

Table 12. Cover types used by radio-marked sage grouse hens that nested successfully and by hens with broods during the early brood period (hatching to 6 weeks of age) at Hart Mountain National Antelope Refuge (n = 12 nests; n = 11 broods and 89 brood observations) and Jackass Creek (n = 7 nests; n = 7 broods and 84 brood observations), Lake and Harney counties, Oregon, 1989-1991.

	Cover types used (%)			
	Hart Mountain		Jackass Creek	
Cover type	Nests	Broods	Nests	Broods
Wyoming big sagebrush	0	2	42[a]	17
Low sagebrush-bunchgrass	8[a]	20	29[a]	54
Mixed sagebrush	0	0	29	29
Mountain big sagebrush	92[a]	30	0	0
Low sagebrush-fescue	0[a]	47	0	0

[a] Use different between successful nests and broods ($P < 0.05$).

Table 13. Cover types and cover types available (%) and used (%) by radio-marked sage grouse hens with broods during the early brood period (hatching to 6 weeks) and the late brood period (7 to 12 weeks after hatching) at Jackass Creek (n = 7 broods and 84 and n = 3 broods and 40 brood observations, respectively), and Hart Mountain National Antelope Refuge (n = 11 broods and 89 observations and n = 4 brood and 40 brood observations, respectively) Lake and Harney counties, Oregon, 1989-1991.

	Jackass Creek				Hart Mountain			
	Early		Late		Early		Late	
Cover type	Available	Used	Available	Used	Available	Used	Available	Used
Wyoming big sagebrush	53[a]	17[b,c,e]	30[a]	45[b]	8	2[c]	0	0
Low sagebrush-bunchgrass	32	54[b,d,e]	30[a]	17[b,c]	43	20[c,e]	0	0
Mixed sagebrush	9[a]	29[b,d]	15[a]	20[b]	<1	0	<1	0
Lakebed	2	0[e]	22[a]	15[b]	<1	0	0	0
Basin big sagebrush	1	0	2	3	<1	0	0	0
Mountain big sagebrush	1[a]	0[b]	0[a]	0[b]	21	30[e]	57	52
Low sagebrush-fescue	0[a]	0[b]	0[a]	0[b]	5	47[d]	16	38[d]
Mountain shrub	0[a]	0	0[a]	0	6	0	2	0
Meadow	1[a]	0	1[a]	0	3	0	5	8
Grassland	0[a]	0	0	0	8	0	<1	3
Juniper/Aspen	1[a]	0	0[a]	0	5	0	19	0

[a] Availability different between study areas ($P < 0.05$).

[b] Use different between study areas ($P < 0.05$).

[c] Use less than expected ($P < 0.05$).

[d] Use greater than expected ($P < 0.05$).

[e] Use different between age periods ($P < 0.05$).

mountain big sagebrush at Hart Mountain had ≤1% availability at Jackass Creek whereas Wyoming big sagebrush and mixed sagebrush at Jackass Creek had ≤8% availability at Hart Mountain. During the late period, all cover types used by hens with broods at Hart Mountain had ≤1% availability at Jackass Creek and no cover types used by broods at Jackass Creek were available at Hart Mountain.

Cover (%) of key forbs measured at random locations was greater in cover types used selectively than in cover types used less than available at both study areas during the early brood period (Table 14 and 15). During the late brood period, cover of forbs (all forbs and key forbs) and grasses were greater in unused cover types than in cover types used by hens with broods at Jackass Creek (Table 14). Conversely, at Hart Mountain, cover of all forbs and grasses was greater in cover types used selectively and used proportionally than in cover types not used; no differences were evident for key forbs (Table 15).

At Hart Mountain, no pattern was evident for selection of habitat components within cover types (Table 16). At Jackass Creek, forb cover was greater at brood sites than at random locations in low sagebrush/bunchgrass and mixed sagebrush during the early brood period (Table 17). During the late brood period, forb cover was greater at brood sites than at random locations in mixed sagebrush (Table 17). In low sagebrush/bunchgrass, availability of key forbs (% cover) was less during the late brood period than during the early brood period, whereas in Wyoming big sagebrush, availability of key forbs was greater during the late brood period than during the early brood period. Analyses for selection of habitat components were also conducted in lakebed and meadow habitats (Appendices F and G).

Availability of forbs and grasses was greater at Hart Mountain than at Jackass Creek during both brood periods (Table 18). During the late brood

Table 14. Habitat characteristics at random sites in cover types used selectively (greater than available), used proportionately (in proportion to availability), used less than available, and unused during the early brood period (hatching to 6 weeks) and late brood period (7 to 12 weeks after hatching) periods by radio-marked sage grouse hens with broods at Jackass Creek, Harney county, Oregon, 1989-1991. Means with same letter or no letter within each category are not different ($P > 0.05$).

	Early[a]			Late[b]		
Characteristic	Used selectively (n=125) $\bar{x}$(SD)	Used < available (n=51) $\bar{x}$(SD)	Unused (n=78) $\bar{x}$(SD)	Used Proportionately (n=109) $\bar{x}$(SD)	Used < available (n=50) $\bar{x}$(SD)	Unused (n=26) $\bar{x}$(SD)
Forb cover (%)						
All forbs	8(6)	9(6)	8(9)	8(10)A	6(4)A	19(13)B
Key forbs[c]	4(4)A	1(1)B	3(4)A	3(2)A	2(2)A	6(8)B
Grass cover (%)	8(6)A	10(6)AB	14(10)B	7(5)A	6(3)A	30(19)B
Shrub cover (%)						
Short, 0-40 cm	24(13)A	5(4)B	5(4)B	11(9)A	28(10)B	3(5)C
Medium, 41-80 cm	7(14)	12(6)	11(10)	10(7)A	1(1)B	2(3)B
Tall, >80 cm	1(5)A	5(6)B	11(8)C	7(10)A	0B	1(1)B

[a] No cover types were used proportionately during the early brood period.
[b] No cover types were used selectively during the late brood period.
[c] Key forbs were analyzed separately.

Table 15. Habitat characteristics at random sites in cover types used selectively (greater than available), used proportionately (in proportion to availability) used less than available, and unused during the early brood period (hatching to 6 weeks) and late brood period (7 to 12 weeks after hatching) by radio-marked sage grouse hens with broods at Hart Mountain National Antelope Refuge, Lake county, Oregon, 1989-1991. Means with same letter or no letter within each category are not different (P > 0.05).

	Early				Late[a]		
Characteristic	Used selectively (n=46) $\bar{x}$(SD)	Used proportionately (n=88) $\bar{x}$(SD)	Used < available (n=54) $\bar{x}$(SD)	Unused (n=117) $\bar{x}$(SD)	Used selectively (n=26) $\bar{x}$(SD)	Used proportionately (n=80) $\bar{x}$(SD)	Unused (n=134) $\bar{x}$(SD)
Forb cover (%)							
All forbs	12(4)A	11(6)A	8(6)B	7(5)B	13(4)A	13(13)A	6(5)B
Key forbs[b]	4(2)A	2(2)B	2(2)B	2(4)B	2(2)	1(2)	2(2)
Grass cover (%)	14(7)A	11(10)B	8(8)C	18(12)A	16(6)A	16(10)A	12(11)B
Shrub cover (%)							
Short, 0-40 cm	15(8)A	17(11)A	7(11)B	9(8)B	20(10)A	13(10)B	8(9)B
Medium, 41-80 cm	0A	16(17)B	19(10)B	13(13)B	0A	6(10)B	11(10)B
Tall, >80 cm	0A	1(2)A	1(1)A	5(8)B	0A	1(2)A	4(7)B

[a] No cover types were used less than available during the laate brood period.
[b] Key forbs were analyzed separately.

Table 16. Habitat characteristics at brood sites and random sites in cover types used by radio-marked sage grouse hens with broods during the early brood period (hatching to 6 weeks) and late brood period (7 to 12 weeks after hatching) at Hart Mountain National Antelope Refuge, Lake county, Oregon, 1989-1991. Means with same letter or no letter within cover types for each habitat characteristic are not different (P > 0.05).

	Cover type									
	Low sagebrush-bunchgrass		Low sagebrush-fescue				Mountain big sagebrush			
Characteristic	Early (n=14)[a] $\bar{x}$(SD)	Random (n=40) $\bar{x}$(SD)	Early (n=46)[a] $\bar{x}$(SD)	Random (n=40) $\bar{x}$(SD)	Late (n=15)[a] $\bar{x}$(SD)	Random (n=26) $\bar{x}$(SD)	Early (n=27)[a] $\bar{x}$(SD)	Random (n=72) $\bar{x}$(SD)	Late (n=21)[a] $\bar{x}$(SD)	Random (n=30) $\bar{x}$(SD)
Forb cover (%)										
All forbs	7(2)	8(5)	12(3)A	12(4)A	19(5)B	13(4)B	14(5)	13(6)	19(4)	14(5)
Key forbs[b]	2(2)	3(2)	3(2)	4(2)	4(4)	2(2)	3(3)	2(1)	4(3)	2(2)
Grass cover (%)	10(3)A	8(4)B	16(6)	14(7)	17(6)	16(6)	15(7)	12(6)	16(8)	13(7)
Shrub cover (%)										
Short, 0-40 cm	21(9)	21(8)	22(8)A	15(8)B	19(9)A	20(10)A	18(9)	17(11)	17(9)	17(9)
Medium, 41-80 cm	0	0	0	0	0	0	9(10)A	17(12)B	14(71)B	16(11)B
Tall, >80 cm	0	0	0	0	0	0	0	1(2)	0	1(4)

[a] Number of brood locations for brood period.

[b] Key forbs were analyzed separately.

Table 17. Habitat characteristics at brood sites and random sites in cover types used by radio-marked sage grouse hens with broods during the early brood period (hatching to 6 weeks) and late brood period (7 to 12 weeks after hatching) periods at Jackass Creek, Harney county, Oregon, 1989-1991. Means with same letter or no letter within cover types for each habitat characteristic are not different (P > 0.05).

	Cover type											
	Low sagebrush-bunchgrass				Mixed sagebrush				Wyoming big sagebrush			
Characteristic	Early (n=44)[a] x̄(SD)	Random (n=74) x̄(SD)	Late (n=7)[a] x̄(SD)	Random (n=50) x̄(SD)	Early (n=23)[a] x̄(SD)	Random (n=51) x̄(SD)	Late (n=7)[a] x̄(SD)	Random (n=30) x̄(SD)	Early (n=16)[a] x̄(SD)	Random (n=51) x̄(SD)	Late (n=18) x̄(SD)	Random (n=27) x̄(SD)
Forb cover (%)												
All forbs	14(5)A	9(5)B	3(1)C	6(2)B	14(4)A	6(4)B	12(4)A	3(2)B	10(4)	9(6)	9(3)	6(2)
Key forbs[b]	7(4)A	5(4)B	1(1)C	2(2)C	5(4)A	3(2)A	5(5)A	1(1)B	1(1)A	1(1)A	3(3)B	2(2)B
Grass cover (%)	8(4)A	6(3)A	3(1)B	6(3)A	9(6)	7(5)	9(5)	6(4)	10(4)	10(6)	11(8)	8(3)
Shrub cover (%)												
Short, 0-40 cm	25(7)A	24(8)A	36(9)B	28(10)B	21(8)A	18(10)A	13(8)B	21(8)A	5(3)	5(4)	5(3)	8(6)
Medium, 41-80 cm	1(1)	1(1)	0	0	6(6)A	5(5)A	12(7)B	9(6)B	15(7)	12(6)	14(7)	13(7)
Tall, >80 cm	0	0	0	0	1(1)	3(7)	4(11)	2(3)	2(4)A	5(6)A	4(5)A	9(10)B

[a] Number of brood observations for that time period.

[b] Key forbs were analyzed separately.

Table 18. Habitat characteristics at random sites in cover types used by radio-marked sage grouse hens with broods during the early brood period (hatching to 6 weeks period) and the late brood period (7 to 12 weeks after hatching) at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1989-1991.

	Early		Late	
Characteristic	Hart Mountain (n=188) $\bar{x}$(SD)	Jackass Creek (n=224) $\bar{x}$(SD)	Hart Mountain (n=106) $\bar{x}$(SD)	Jackass Creek (n=132) $\bar{x}$(SD)
Forb cover (%)				
All forbs	12(8)[a]	8(7)	13(12)[a]	7(9)
Key forbs[b]	2(2)	2(2)	3(2)	2(2)
Grass cover (%)	13(8)[a]	9(3)	16(10)[a]	7(5)
Shrub cover (%)				
Short, 0-40 cm	16(9)[a]	21(12)	15(11)	17(12)
Medium, 41-80 cm	13(10)	17(10)	5(9)	7(8)
Tall, >80 cm	1(2)[a]	3(7)	1(2)[a]	5(9)

[a] Mean different between study areas ($P < 0.05$)

[b] Key forbs were analyzed separately.

period, cover of all forbs at brood sites was greater at Hart Mountain than at Jackass Creek (Table 19). Further, grass cover at brood sites and random locations was greater at Hart Mountain than Jackass Creek during both brood-rearing periods (Table 18 and 19).

Analyses for selection of cover types and habitat components by hens with broods were also conducted with data obtained from brood routes and broods randomly observed on both study areas (Appendices H and I).

DISCUSSION

Results of this study indicated that hens with broods selected cover types and selection was influenced by availability of forbs. During the early brood period at both study areas, hens with broods selected for cover types with a short shrub component (low sagebrush/fescue at Hart Mountain and low sagebrush/bunchgrass and mixed sagebrush at Jackass Creek), which had a greater availability of key forbs than cover types used less than available. During the late brood period, availability of forbs remained high in low sagebrush/fescue at Hart Mountain and consequently, was the only cover type used selectively. However, at Jackass Creek, forb availability changed in the late brood period. Wyoming big sagebrush had greater availability of key forbs than low sagebrush/bunchgrass and, as a result, hens with brood increased use of Wyoming big sagebrush and decreased use of low sagebrush/bunchgrass.

Forbs are a critical part of the diet of juvenile sage grouse during summer (Rasmussen and Griner 1938, Patterson 1952:201, Peterson 1970). Peterson (1970) reported that an abundance and diversity of forbs were an important component of juvenile sage grouse habitat. Klebenow (1969) reported that broods in Idaho were found where forb availability was greatest. Further, previous studies that dealt with habitat use by sage grouse hens with

Table 19. Habitat characteristics at brood sites in cover types used by radio-marked sage grouse hens with broods during the early brood period (hatching to 6 weeks period) and the the late brood rearing (7 to 12 weeks after hatching) at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1989-1991.

	Early		Late	
Characteristic	Hart Mountain (n=87) $\bar{x}$(SD)	Jackass Creek (n=84) $\bar{x}$(SD)	Hart Mountain (n=38) $\bar{x}$(SD)	Jackass Creek (n=38) $\bar{x}$(SD)
Forb cover (%)				
All forbs	11(7)	13(6)	20(8)[a]	8(6)
Key forbs[b]	3(2)	3(4)	3(3)	2(3)
Grass cover (%)	15(7)[a]	9(5)	16(7)[a]	8(5)
Shrub cover (%)				
Short, 0-40 cm	20(9)	21(10)	16(9)	14(14)
Medium, 41-80 cm	3(7)	4(6)	8(10)	12(10)
Tall, >80 cm	0[a]	1(2)[a]	0[a]	3(6)

[a] Mean different between study areas ($P < 0.05$)

[b] Key forbs were analyzed separately.

broods revealed changes in cover type use throughout summer and the changes were associated with phenology and desiccation of forbs. In Idaho, broods were increasingly found in bitter-brush habitats as summer progressed because of greater availability of green forbs than in sagebrush habitats (Klebenow 1969). Further, broods moved to higher elevations as forbs desiccated at lower elevations (Klebenow 1969, Autenrieth 1981:21). In Montana, hens with broods used greasewood (Sarcobatus vermiculatus) bottoms and alfalfa (Medicago sativa) fields when desiccation decreased availability of forbs in sagebrush uplands (Peterson 1970, Wallestad 1971).

Sagebrush height may be an additional factor involved with habitat selection by hens with broods. Most successful nests were located in big sagebrush cover types, but immediately after hatching hens with broods moved to low sagebrush cover types. As broods matured beyond 6 weeks of age, use of big sagebrush cover types increased. These changes in cover type use may be associated to predator avoidance when chicks are young and the need for thermal cover later in the summer.

Previous authors reported changes in sagebrush height and canopy cover at brood sites over time. In Idaho, broods used sagebrush with a canopy cover of 6% and height of 15-30 cm in June, but used sagebrush with a canopy cover of 12% and a height of 30-45 cm in August (Peterson 1970). Wallestad (1971) also reported that sagebrush height and canopy cover were greater at brood sites in late summer than in early summer. These changes in sagebrush height and cover were associated with changes in vegetation types used by broods during summer. In Idaho, hens with broods used stands with less shrub canopy cover than typically found in available habitat (Klebenow 1969). Canopy cover of shrubs did not appear to be a factor in habitat selection in this study.

At Hart Mountain, no difference in forb cover was detected between brood sites and random sites within cover types. However, at Jackass Creek, forb

cover was greater at brood sites than at random sites within cover types. These differences in habitat selection between study areas were attributed to differences in forb availability. Availability of forbs was greater at Hart Mountain than at Jackass Creek during both brood periods. Cover types used at Hart Mountain (low sagebrush/fescue and mountain big sagebrush) were available at higher elevations (>1800 m) and had greater amounts of precipitation, which increased forb production and delayed forb phenology. Because forb availability was relatively high at Hart Mountain, hens with broods were not selective for forb cover within cover types. Cover types used by broods at Jackass Creek were not used or were used less than available at Hart Mountain because of lower forb availability, although those cover types were structurally similar (e.g. low sagebrush/bunchgrass was used selectively at Jackass Creek but used less than available at Hart Mountain). However, hens with broods at Jackass Creek selected sites with greater forb cover within cover types. Forb cover (all forbs and key forbs) at brood sites approximated forb availability at Hart Mountain, and may represent minimum forb cover required for brood habitat.

Differences in brood production between study areas (since 1981) may be related to differences in availability of forbs. During the early brood period, forb cover at brood sites was similar between study areas. However, home range size of broods was greater at Jackass Creek than at Hart Mountain. During the late brood period, forb cover at brood sites was greater and home range size was smaller at Hart Mountain than at Jackass Creek. At Jackass Creek, forb availability was low and hens with broods had to move farther to locate areas with forbs. Drought conditions at Jackass Creek, which reduced forb availability, potentially was responsible for the large movements by broods. Home range size decreased at Hart Mountain during the late period because forbs remained available at upland sites and meadows; hence, broods

were able to concentrate in areas with succulent forbs. In Montana, home range size of sage grouse broods decreased from 85 ha in June to 51 ha by August (Wallestad 1971). In Colorado, May and Poole (1969) reported that hens with broods did not leave once they reached hay meadows. Larger home ranges at Jackass Creek indicated hens with chicks spent a greater amount time searching for food and thus, were exposed to predators longer and expended greater amounts of energy, which may contribute to reduced survival. The relatively low survival of chicks at Hart Mountain was likely associated with abiotic factors such as weather. Four broods were lost just after hatching because of severe weather at high elevations, where most successful nests were located.

Differences in forb availability between study areas also was reflected in the diets of sage grouse chicks collected from each area. Forbs and insects represented a smaller proportion of the diet of chicks at Jackass Creek (23% and 12%, respectively) than at Hart Mountain (50% and 22%, respectively). Conversely, sagebrush represented a larger proportion of the diet at Jackass Creek (65%) than at Hart Mountain (28%) (M. S. Drut, Oreg. State Univ., unpubl. data). Forbs and insects provide essential nutrients and are more easily digested by chicks than grasses or shrubs and lack of these items in chick diets may negatively influence survival (Klebenow and Gray 1968, Peterson 1970) and may explain differences in productivity between the 2 study areas since 1980.

Mixed sagebrush at Jackass Creek was the most structurally diverse cover type available. Selective use by hens with broods during the early brood rearing period and continued use into the late brood period indicated mixed sagebrush had characteristics desirable to hens with broods. Mixed sagebrush potentially maintained a consistent availability of forbs because of the low sagebrush and big sagebrush mixture. Use of mixed sagebrush, which had

heterogenous characteristics, differed from results of Dunn and Braun (1986) in Colorado, who reported broods selected homogeneous stands of sagebrush.

Importance of riparian areas to broods was documented by increased use of lakebeds and meadows during the late brood-rearing period. At Jackass Creek, availability of lakebeds was greater during the late brood period than during the early brood period and were the only riparian areas available at Jackass Creek. However, during drought conditions experienced in 1990 and 1991, lakebeds were devoid of forbs. Meadows had greater forb cover than all cover types used during the late brood period on both study areas. However, meadows were in poor condition and represented only 1% of the available habitat at Jackass Creek. During drought years, lack of meadow habitat at Jackass Creek may have a negative effect on chick survival. Meadows were important habitats in Nevada (Oakleaf 1971, Evans 1986). However, meadows were not used selectively by radio-marked hens with broods at Hart Mountain because succulent forbs remained available in sagebrush cover types during the late brood period. Further, brood integrity was lost before forb desiccation occurred in sagebrush uplands.

CHAPTER FOUR

SUMMER HABITAT USE AND SELECTION BY BROODLESS HENS

Productivity of sage grouse is among the lowest of North American grouse (Edminster 1954:130). Nest failure ranged from 76% in Oregon (Batterson and Morse 1948) to 36% (Wallestad and Pyrah 1974) in Montana. In fall populations, 1.3 to 1.5 chicks for each adult is typical (Edminster 1954:130). Consequently, a relatively large percentage of summer sage grouse populations consist of broodless hens. Sage grouse are long-lived compared with other species of grouse. In Montana, Wallestad (1975) reported a marked hen that survived for 8 years, and in Oregon, 2 radio-marked hens survived >5 years (G. P. Keister, Oreg. Dept. Fish and Wildl., unpubl. data). Because hens without broods in one year may recruit broods in subsequent breeding seasons, survival of hens may be critical to population stability. However, information on broodless hens is largely anecdotal. Only observations of the proximity of broodless hens to hens with broods (Dalke et al. 1963, Martin 1976) and chronology of summer movements by broodless hens (Peterson 1980 and Connelly et al. 1988) have been reported. No study has dealt specifically with habitat use by broodless sage grouse hens. This information is important in order to gain a better understanding of habitat use by sage grouse; thus, allowing for enhancement of populations through sound land management practices. We hypothesized that broodless sage grouse hens selected cover types (third-order selection) and habitat characteristics within cover types (fourth-order selection), and that selection differed between broodless hens and hens with broods. Our objectives were to identify cover types used by broodless hens in relation to availability, to identify habitat characteristics at broodless hen sites and compare to randomly selected locations, and to assess habitat use by broodless hens in relation to hens with broods.

DATA ANALYSIS

Relative proportions of cover types used by broodless hens were compared with availability of cover types within study areas and cover type use was compared between broodless hens and hens with broods with Chi-square analysis. Cover types with expected values less than 5 were combined and analyzed collectively. If differences were detected, confidence intervals were calculated to identify cover types that contributed to the difference (Neu et al. 1974, Byers et al. 1984).

Habitat characteristics at broodless hen locations were compared with those at random locations with a factorial analysis of variance (ANOVA) (Snedecor and Cochran 1980:339); plot type (broodless hen or random) was the main affect and study area was an additional factor. Further, habitat characteristics measured at random locations in cover types used by broodless hens were compared between study areas with ANOVA. All of our data were normally distributed and we considered our results significant if $P \leq 0.05$.

RESULTS

One-hundred-fourteen radio-marked broodless hens (67 at Hart Mountain and 47 at Jackass Creek) were relocated 305 times (168 locations at Hart Mountain and 137 locations at Jackass Creek) during summers (June-July) of 1989-91. Seven radio-marked hens with broods at Hart Mountain were relocated 90 times and 4 at Jackass Creek were relocated 55 times during the same time period. Available habitat encompassed 393 km^2 at Hart Mountain and 563 km^2 at Jackass Creek. Habitat characteristics were measured at 112 broodless hen sites (22 locations from 13 hens at Hart Mountain and 90 locations from 33 hens at Jackass Creek) and 100 random locations (30 and 70 at Hart Mountain and Jackass Creek, respectively).

Small flocks of broodless hens (2-3 birds) were first observed in mid-May at both study areas. By early June, flocks of 25 broodless hens were commonly found in low sagebrush, big sagebrush, and mixed sagebrush cover types. Broodless hens remained near hens with broods until early July and then moved to meadows. Numbers of broodless hens in meadows increased and by late July flocks of >100 were observed. Hens with broods remained in upland sagebrush habitats until early August then moved to meadows and joined broodless hens.

Broodless hens used mountain big sagebrush, low sagebrush/fescue, and meadow habitats at Hart Mountain and mixed sagebrush at Jackass Creek more frequently than expected (Table 20). Low sagebrush/bunchgrass was used less frequently than expected at both study areas (Table 20). Cover type use differed between broodless hens and hens with broods (Table 21). Broodless hens used less low sagebrush/fescue and more low sagebrush/bunchgrass, grassland, and meadow than hens with broods at Hart Mountain and used more mixed sagebrush than hens with broods at Jackass Creek.

A significant study area interaction was detected for forb cover. At Jackass Creek, forb cover (%) was greater at broodless hen sites ($\bar{x}$ = 4, SD = 4, n = 90) than random locations ($\bar{x}$ = 2, SD = 3, n = 70). However, at Hart Mountain, forb cover did not differ between broodless hen ($\bar{x}$ = 10, SD = 6, n = 22) and random ($\bar{x}$ = 12, SD = 9, n = 30) locations. No differences in other habitat characteristics were detected between broodless hen and random sites (Table 22). Cover of forbs, grasses, and short shrubs was greater and tall shrubs was less in cover types used at Hart Mountain than at Jackass Creek (Table 23).

Table 20. Cover types, cover types available, and use of cover types in June-August by 67 and 47 radio-marked broodless sage grouse hens at Hart Mountain National Antelope Refuge (n = 168 locations) and Jackass Creek (n = 137 locations), respectively, Lake and Harney counties, Oregon, 1989-91.

Cover type	Hart Mountain		Jackass Creek	
	% Available	% Used	% Available	% Used
Low sagebrush/bunchgrass	44	30[a]	37	18[a]
Wyoming big sagebrush	0	0	41	36
Mountain big sagebrush	20	34[b]	0	0
Mixed sagebrush	0	0	11	39[b]
Grassland	12	8	0	0
Low sagebrush/fescue	5	15[b]	0	0
Meadow	3	10[b]	0	0
Other[c]	16	2[a]	11	8

[a] Used less than expected ($P < 0.05$).
[b] Used greater than expected ($P < 0.05$).
[c] Includes juniper/aspen, basin big sagebrush, and grassland.

Table 21. Cover types and use of cover types in June-August by radio-marked broodless sage grouse hens and hens with broods at Hart Mountain National Antelope Refuge (n = 67 and n = 7, respectively) and Jackass Creek (n = 47 and n = 4, respectively), Lake and Harney counties, Oregon, 1989-91.

Cover type	Hart Mountain		Jackass Creek	
	% use Broodless (n=168)[a]	% use Brood (n=94)	% use Broodless (n=137)	% use Brood (n=55)
Low sagebrush/bunchgrass	30[b]	6	18	24
Wyoming big sagebrush	0	0	36	42
Mountain big sagebrush	34	40	0	0
Mixed sagebrush	0	0	39[b]	22
Grassland	8[b]	1	0	0
Low sagebrush/fescue	15[c]	49	0	0
Meadow	10[b]	3	0	0
Other[d]	2	0	8	13

[a] Number of locations.
[b] Use greater than hens with broods ($P < 0.05$).
[c] Use less than hens with broods ($P < 0.05$).
[d] Includes Juniper/aspen, basin big sagebrush, and grassland.

Table 22. Habitat characteristics (% cover) at summer (June-August) use sites of radio-marked broodless sage grouse hens and random locations at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1990.

	Broodless hen (n = 112)		Random (n = 100)	
Characteristic	$\bar{x}$	SD	$\bar{x}$	SD
Forb cover[a]	5	5	5	7
Grass cover	10	9	9	6
Shrub cover				
Short, < 40 cm	14	10	14	10
Medium, 40-80 cm	11	8	8	9
Tall, > 80 cm	4	6	3	5

[a] Significant study area interaction was detected; forb cover was greater at broodless hen sites than random locations at Jackass Creek but not at Hart Mountain. No differences were found for other habitat characteristics.

Table 23. Habitat characteristics (% cover) at random locations measured during July in cover types used by radio-marked broodless sage grouse hens at Hart Mountain National Antelope Refuge and Jackass Creek, Lake and Harney counties, Oregon, 1990.

	Hart Mountain (n = 30)		Jackass Creek (n = 70)	
Characteristic	$\bar{x}$	SD	$\bar{x}$	SD
Forb cover	12[a]	9	2	3
Grass cover	13[a]	9	7	3
Shrub cover				
Short, < 40 cm	19[a]	10	12	10
Medium, 40-80 cm	6	12	9	8
Tall, > 80 cm	1[a]	1	4	6

[a] Means different between study areas ($P < 0.05$).

DISCUSSION

Results of this study indicated that broodless hens selected mountain big sagebrush, low sagebrush/fescue, and meadow habitats at Hart Mountain and mixed sagebrush at Jackass Creek. Broodless hens did not select for particular habitat characteristics within cover types at Hart Mountain. However, at Jackass Creek, forb cover was greater at broodless hens sites than at random locations. Broodless hens also used a greater diversity of cover types than hens with broods.

Differences in habitat use between areas observed in this study were attributed to differences in forb availability. Forbs are an important component of the diet of hens during summer (Patterson 1952:203, Wallestad et al. 1975). In Montana, sage grouse shifted from a diet of sagebrush to forbs in summer (Wallestad 1975). The change was attributed to availability and palatability of forbs. In cover types used selectively at Hart Mountain, forb availability was relatively high and broodless hens did not select sites within cover types on the basis of forb availability. These cover types (mountain big sagebrush, low sagebrush/fescue, and meadow) were available at higher elevations and received greater amounts of precipitation, which increased forb production and delayed forb phenology compared with low elevation sites. However, in order to satisfy dietary needs at Jackass Creek, where forb availability was low, broodless hens selected sites with greater forb cover within cover types. Differences in grass cover between areas was also reflective of greater productivity in cover types at higher elevations at Hart Mountain.

Broodless hens selected big and low sagebrush cover types during summer. These results were concordant with observations of previous authors. In Montana, Wallestad (1975) reported flocks of unsuccessful hens were typically found in areas of dense sagebrush throughout summer but no data were

presented. In Nevada, Klebenow (1972) noted that broodless hens fed in open areas of low sagebrush and roosted in dense clumps or patches of big sagebrush. In Colorado, Schoenberg (1982) reported greater sagebrush cover at broodless hen sites than at random sites. However, our findings indicated broodless hens did not select sites based on canopy cover of shrubs. Differences in canopy cover of short and tall shrubs at random sites between study areas was reflective of cover types used at the two areas. Canopy cover of all height classes of shrubs combined was similar at Hart Mountain (26%) and Jackass Creek (25%).

The greater diversity of cover types used by broodless hens than hens with broods may be attributed to specific habitat requirements of juvenile sage grouse. Other authors reported juvenile sage grouse relied on forbs and insects during summer (Rasmussen and Griner 1938, Patterson 1952:201, Peterson 1970). Hens with broods selected areas with less sagebrush (Klebenow 1969, Wallestad 1971, Martin 1976) and greater availability of forbs (Klebenow 1969, Peterson 1970, Wallestad 1971). Habitat needs of broodless hens apparently are less specific than that of hens with broods and as a consequence, broodless hens used a greater diversity of cover types.

Broodless hens gathered in flocks and remained separate from but in the same general vicinity of hens with broods during early summer. Dalke et al. (1963) in Idaho and Martin (1976) in Montana reported that nonreproductive females spent the summer in small flocks separate from broods. In Oregon, Batterson and Morse (1948) found females without young separate from broods but in the same general area. Movement of broodless hens to meadows before hens with broods reported here was also noted by Connelly et al. (1988) in Idaho, where females without broods arrived on summer range before females with broods. Further, Peterson (1980) reported that all radio-marked broodless hens in his Idaho study moved into meadows and the movement was

related to nest loss and not desiccation of vegetation. Hens with broods also moved to meadows, but the movement was related to vegetation desiccation (Peterson 1980). Presumably, hens with broods remained in uplands until succulent forbs were no longer available, then moved to meadows later in the summer. In contrast, Schoenberg (1982) noted that movements of broodless hens and hens with broods occurred simultaneously and was probably a response to vegetation desiccation in sagebrush uplands.

CONCLUSIONS

Results of this research revealed that sage grouse used a diversity of cover types and specific habitat components within cover types for successful reproduction. Sage grouse apparently require stands of medium height (40-80 cm) sagebrush with an understory of tall (>18 cm) residual bunchgrasses for successful nesting. Hens with broods and broodless hens use a diversity of low and big sagebrush cover types that provide forbs for food throughout summer. Finally, meadows and lakebeds are important habitats for sage grouse during late summer after forbs in uplands have desiccated and are no longer available. To enhance sage grouse populations in Oregon, management for breeding habitat must take into account all requirements necessary for successful reproduction.

Historically, sage grouse habitat (i.e., sagebrush-steppe ecosystems) was a natural mosaic of habitats ranging from sagebrush-bunchgrass communities to early seral annual forb communities. This mosaic of habitats was maintained by fire, which was a natural component of healthy sagebrush-steppe ecosystems (Winward 1985, Kauffman 1990). Fires left islands and stringers unburned and areas that did burn received various intensities of fire (Winward 1991). Fire return intervals ranged from 32-70 years or more in xeric low elevation Wyoming big sagebrush habitats to 10-25 years in mesic high elevation mountain big sagebrush habitats (Houston 1973, Wright et al. 1979, Kauffman 1990, Winward 1991). Euroamerican settlement greatly changed sagebrush-steppe ecosystems (Kauffman 1990). In Oregon, mosaics of sagebrush communities in different seral stages changed to homogenous stands of dense sagebrush with little or no herbaceous understory as a result of overgrazing by domestic livestock and fire suppression. Therefore, an ecosystem or landscape approach to management is required to restore the natural mosaic of

sagebrush stands that existed before settlement (Young 1990) and to enhance sage grouse populations in Oregon.

MANAGEMENT IMPLICATIONS

Grazing by domestic livestock, fire, and sagebrush control are land management practices that influence cover-type diversity (mosaics) and shrub and herbaceous understory cover throughout sagebrush-steppe ecosystems. Grazing by domestic livestock potentially has the greatest impact on sage grouse habitat because it remains the most common and widespread use of rangelands in Oregon (Galbraith and Anderson 1971). The relationship between the grass component of the habitat and sage grouse nesting success observed in this study suggests that reduction of tall grass cover negatively influence sage grouse productivity. This result implies that factors which cause decreased tall grass cover at potential nest sites could adversely impact sage grouse populations because of increased nest predation. Conversely, these results also imply that this enhancement of tall grass cover would result in greater nest success of sage grouse through a reduction of the proximate cause of nest loss, namely avian and mammalian predation.

Livestock grazing is the principal land management practice and proximate factor that affects grass cover and height (Rickard et al. 1975). Moderate grazing enhances forb availability in upland meadows during late summer; however, meadows with dense shrub cover and steep stream banks associated with overgrazing were avoided by broods (Klebenow 1985, Evans 1986). Long-term effects of overgrazing on upland habitats include loss of herbaceous understory vegetation and changes in habitat structure (Patterson 1952:274; Autenrieth et al. 1982; Klebenow 1982, 1985). During the period of heavy grazing by livestock (early 1900s) many understory species were reduced in abundance (Winward 1991). This loss of fine fuels along with active fire

suppression allowed for increased canopy cover and densities of shrubs, particularly sagebrush and western juniper (Kauffman 1990). These changes associated with long-term overgrazing created habitat unsuitable to sage grouse (Autenrieth 1981).

Wildfires that once created and maintained a mosaic of habitats, now remove large tracts (thousands of hectares) of sagebrush. These areas are often reseeded to crested wheatgrass (Agropyron desertorum) to provide forage for domestic livestock and are lost as sage grouse habitat (Wallestad 1971, Braun et al. 1977, Martin 1976). Introduction of exotic annuals (e.g. cheatgrass, Bromus tectorum) have increased fire frequencies in some areas (Kauffman 1990). Once introduced, cheatgrass often out competes native plants and maintains a frequent fire cycle that perpetuates cheatgrass. Monocultures of cheatgrass lack the habitat components of sage grouse breeding habitat. Fire also increases the invasion of other exotics such as knapweed (Centaurea spp.), which negatively affects forb cover (Hoffman 1991). Fire can, however, be used as a management tool to open dense stands of sagebrush and create habitat mosaics, and increase availability of some forbs and grasses (Klebenow 1970, 1972; Wright et al. 1979, Winward 1985, Kauffman 1990). Reintroduction of fire may act to create diverse stands of different seral stages in juxtaposition that improves brood habitat by increasing forb availability and improves nesting habitat by promoting favorable understory conditions (Klebenow 1985).

The importance of sagebrush as the primary component of sage grouse habitat is well documented, as it is important throughout the breeding season for food and cover. Virtually every study that examined the effects of sagebrush removal on sage grouse populations concluded that sage grouse populations were detrimentally affected (Rogers 1964; Klebenow 1970; Martin 1970; Pyrah 1971; Wallestad 1971, 1975). The primary factors that affect

sagebrush ecosystems are eradication of sagebrush for agricultural production, increased livestock forage, urban development, and mining activities. These practices will negatively impact sage grouse populations by loss of medium height shrub cover and tall grass cover for nesting and loss of cover type diversity and forb cover for brood-rearing.

Most sage grouse habitat in Oregon is public land and continuation of current land-management practices will not afford recovery of sage grouse populations. Management practices that positively influence cover type diversity (prescribed fire) and native perennial grass and forb understory (reduction of cattle grazing) on an ecosystem or landscape scale are required to regain healthy sage grouse populations in Oregon.

MANAGEMENT RECOMMENDATIONS

1) Maintain or develop stands consisting of 8-12% cover of Wyoming big sagebrush and 15-20% cover of mountain and basin big sagebrush (Winward 1991) to provide nesting habitat with medium height (40-80 cm) sagebrush and tall (>18 cm) residual grass cover.

2) Maintain or develop a mosaic of low and big sagebrush habitats or big sagebrush habitats in an array of seral stages to provide 12-14% forb cover for hens with broods and broodless hens throughout the breeding season.

3) Protect riparian habitats (lakebeds and meadows) from excessive grazing and rehabilitate riparian habitats in poor condition. These habitats are critical brood-rearing and summer use areas in regions with low annual rainfall and during drought years.

4) Develop fire prescriptions (Wright et al. 1979, Winward 1985, Young 1990) that can be used to create a mosaic of habitats and return sagebrush canopies to levels that are compatible with a healthy understory of native annual and perennial grasses and forbs. Exotic annuals (e.g., cheatgrass) must be considered in all fire prescriptions. In areas where fire is not feasible or practical, other methods (mechanical) of thinning sagebrush should be considered.

5) Design programs for grazing by domestic livestock on Oregon rangelands to achieve a more favorable ecological balance in the shrub canopy and herbaceous understory.

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Appendix A. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during May at Hart Mountain National Antelope Refuge, Lake county, Oregon, 1989-1991.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	40	Collinsia	0.8	50
		Sitanion	1.3	27
		Poa	5.0	88
		Phlox	2.5	43
Low sagebrush/fescue	40	Agoseris	0.5	32
		Arenaria	0.8	25
		Astragalus	1.6	43
		Crepis	0.8	30
		Festuca	9.6	87
		Phlox	3.8	72
		Poa	3.6	86
		Sitanion	0.9	28
Mountain shrub	41	Agoseris	0.5	25
		Agropyron	1.3	18
		Bromus	3.2	48
		Collinsia	1.2	65
		Festuca	1.5	8
		Poa	6.2	61
		Sitanion	3.0	36
		Stipa	2.6	24
Mountain big sagebrush	72	Agoseris	0.7	36
		Agropyron	1.5	33
		Balsamorhiza	1.3	6
		Collinsia	1.0	54
		Eriogonum	1.2	15
		Festuca	3.4	26
		Lupinus	2.4	52
		Poa	3.0	47
		Sitanion	1.4	30
		Senecio	1.0	29
Wyoming big sagebrush	34	Collinsia	0.7	45
		Musci	3.4	13
		Poa	1.5	42
		Sitanion	0.9	30
Grassland	30	Agropyron	1.8	8
		Bromus	8.5	58
		Carex	1.6	10
		Microsteris	1.1	46
		Poa	5.1	51
		Sitanion	3.0	34
Lakebed	20	Juncus	1.3	52

Appendix A. (continued)

Cover type	n	Genus	Cover	Frequency
Meadow	20	Achillea	4.1	44
		Agropyron	2.7	35
		Aster	1.3	18
		Carex	5.8	41
		Haplopappus	2.0	19
		Iris	1.1	14
		Juncas	4.5	64
		Koeleria	1.2	14
		Poa	10.6	81
		Potentilla	4.7	38
Basin big sagebrush	30	Bromus	1.4	17
		Collinsia	0.7	42
		Elymus	1.3	6
		Festuca	2.4	14
		Microsteris	1.2	49
		Musci	2.3	9
		Phlox	1.7	23
		Poa	3.7	32
		Sitanion	2.9	29
		Stipa	2.5	14

Appendix B. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during May at Jackass Creek study area, Harney county, Oregon, 1989-1991.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	69	Collinsia	1.5	63
		Lomatium	1.2	29
		Microsteris	0.7	31
		Musci	1.4	16
		Poa	5.7	92
		Phlox	0.9	25
Wyoming big sagebrush	46	Bromus	1.2	21
		Collinsia	1.0	38
		Lomatium	1.4	30
		Microsteris	1.0	37
		Musci	1.6	8
		Poa	7.2	70
		Sitanion	1.4	26
		Stipa	2.3	16
Mixed sagebrush	46	Collinsia	0.6	36
		Lomatium	1.3	33
		Microsteris	0.7	36
		Musci	1.2	10
		Phlox	0.7	24
		Poa	5.6	74
		Sitanion	1.6	31
		Stipa	1.2	19
Basin big sagebrush	36	Bromus	2.8	35
		Collinsia	1.4	34
		Microsteris	1.0	28
		Poa	11.5	72
		Polemonium	1.3	22
		Sitanion	3.1	38
Lakebed	22	Musci	1.0	5

Appendix C. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during July at Hart Mountain National Antelope Refuge, Lake county, Oregon, 1989-1990.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	30	Collinsia	0.5	41
		Musci	1.0	15
		Phlox	0.8	28
		Poa	5.0	86
		Sitanion	1.3	27
Low sagebrush/fescue	26	Arenaria	0.5	12
		Collinsia	0.3	11
		Festuca	9.4	81
		Phlox	4.3	59
		Poa	4.4	82
		Sitanion	0.9	20
Mountain big sagebrush	30	Antennaria	1.1	8
		Collinsia	0.3	27
		Festuca	4.7	38
		Lupinus	5.0	61
		Poa	3.8	62
		Senecio	1.0	26
		Sitanion	2.2	43
Basin big sagebrush	27	Bromus	1.6	28
		Carex	1.9	17
		Collinsia	0.9	56
		Gayophytum	0.3	16
		Lupinus	2.1	24
		Microsteris	1.2	52
		Poa	6.2	51
		Polemonium	1.0	25
		Sitanion	4.4	54
Lakebed	25	Cryptantha	0.5	16
		Downingia	0.6	16
		Juncus	2.1	30
		Musci	1.9	7
		Myosurus	5.0	19
		Navarretia	2.0	31
		Oenothera	1.3	7
		Polygonum	1.9	38
		Psilocarphus	1.2	30
Grassland	30	Bromus	8.1	71
		Epilobium	0.5	19
		Lupinus	0.7	18
		Microsteris	0.4	27
		Poa	2.8	38
		Sitanion	3.1	34

Appendix C. (continued)

Cover type	n	Genus	Cover	Frequency
Mountain shrub	30	Bromus	6.2	39
		Collinsia	0.5	35
		Festuca	2.8	15
		Microsteris	0.4	21
		Poa	7.2	65
		Sitanion	3.6	37
		Stipa	3.5	28
Wyoming big sagebrush	23	Bromus	0.6	23
		Collinsia	0.3	19
		Musci	0.9	14
		Phlox	0.3	11
		Poa	0.7	28
		Sitanion	1.0	30
Meadow	20	Achillea	0.9	20
		Agropyron	2.8	33
		Aster	0.5	13
		Carex	8.9	36
		Haplopappus	1.3	15
		Iris	1.9	20
		Juncus	0.8	50
		Lomatium	0.4	15
		Penstemon	0.4	13
		Poa	12.1	86
		Potentilla	3.1	38

Appendix D. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during July at Jackass Creek study area, Harney county, Oregon, 1989-1990.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	50	Collinsia	0.7	49
		Poa	4.0	88
		Sitanion	1.2	30
Mixed sagebrush	30	Collinsia	0.4	23
		Phlox	0.5	14
		Poa	4.2	86
		Sitanion	0.7	12
Wyoming big sagebrush	27	Collinsia	0.6	60
		Musci	0.8	10
		Poa	5.3	78
		Sitanion	1.4	37
Basin big sagebrush	27	Bromus	1.6	28
		Carex	1.9	17
		Collinsia	0.9	56
		Gayophytum	0.3	16
		Lupinus	2.1	24
		Microsteris	1.2	52
		Poa	6.2	51
		Polemonium	1.0	25
		Sitanion	4.4	54
Lakebed	25	Cryptantha	0.5	16
		Downingia	0.6	16
		Juncus	2.1	30
		Musci	1.9	7
		Myosurus	5.0	19
		Navarretia	2.0	31
		Oenothera	1.3	7
		Polygonum	1.9	38
		Psilocarphus	1.2	30
Meadow	26	Achillea	0.7	14
		Carex	4.5	23
		Juncus	12.6	41
		Microsteris	0.5	13
		Poa	12.8	64
		Taraxacum	1.4	21
		Trifolium	3.1	22

Appendix E. Availability of tall (>18 cm) and short (<18 cm) grass genera during May in cover types used for nesting by radio-marked female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, Oregon, 1989-1991. Sample size represents number of random locations sampled in each cover type.

	Hart Mountain						Jackass Creek					
	LSB[a] n=40		MSB[b] n=72		MS[c] n=41		LSB N=74		WBS[d] n=51		MC[e] n=51	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Tall Genera												
Elymus	0		0.3	3.9	0.2	2.5	0		0.1	0.6	0	
Agropyron	0.3	1.9	1.3	3.8	1.0	3.3	0		0		0	
Festuca	0		4.0	9.8	1.2	6.7	0		0		0	
Stipa	0.5	2.7	0.6	3.2	2.3	6.1	0.4	2.3	1.7	7.0	0.9	3.3
Short Genera												
Sitaman	1.7	5.2	1.4	3.3	3.2	8.4	0.8	2.0	1.2	3.0	1.2	3.2
Koelina	0.1	0.9	0.2	1.3	0.1	1.3	0		0		0	
Bromus	0.1	0.6	0.8	3.3	2.5	7.2	0.1	0.6	0.9	3.4	0.3	1.9
Poaa	4.8	5.4	3.0	5.3	6.8	8.8	5.2	4.7	6.1	8.8	4.9	6.1

[a]Low sagebrush bunchgrass

[b]Mountain big sagebrush

[c]Mountain shrub

[d]Wyoming big sagebrush

[e]Mixed sagebrush

Appendix F. Habitat characteristics at brood sites (n=6) and random sites (n=25) in lakebeds during the late brood period (7 to 12 weeks after hatching) at Jackass Creek, Harney county, Oregon, 1989-1990. Means with same letter or no letter for each habitat characteristic are not different ($P > 0.05$).

	Brood		Random	
Characteristic	$\bar{x}$	(SD)	$\bar{x}$	(SD)
Forb cover (%)				
All forbs	2	(3)A	14	(14)B
Key forbs	2	(2)	1	(2)
Grass cover (%)	6	(4)	4	(5)
Shrub cover (%)				
Short, 0-40 cm	23	(13)A	11	(10)B
Medium, 41-80 cm	20	(13)A	10	(10)B
Tall, >80 cm	0		>1	

Appendix G. Habitat characteristics at brood sites (n = 3) and random sites (n = 20) in meadows during the late brood period (7 to 12 weeks after hatching) at Hart Mountain National Antelope Refuge, Lake county, Oregon, 1989-1990. Means with same letter or no letter for each habitat characteristic are not different (P > 0.05).

Characteristic	Brood $\bar{x}$ (SD)	Random $\bar{x}$ (SD)
Forb cover (%)		
All forbs	27 (9)	21 (17)
Key forbs	16 (3)	21 (15)
Grass cover (%)	4 (3)A	1 (1)B
Shrub cover (%)		
Short, 0-40 cm	>1	>1
Medium, 41-80 cm	0	0
Tall, >80 cm	0	0

Appendix H. Cover types available and used by hens with broods observed on transects and hens with broods randomly observed at Hart Mountain National Antelope Refuge (n = 32 and 26, respectively) and Jackass Creek (n = 32 and 15, respectively) study areas, Lake and Harney counties, Oregon, 1989-1991.

	Hart Mountain				Jackass Creek			
	Transects		Random broods		Transects		Random broods[a]	
Cover type	% Available	% Used	% Available	% Used	% Available	% Used	% Available	% Used
Low sagebrush-bunchgrass	23	19	38	0	41	31	33	27
Wyoming big sagebrush	11	0	7	0	39	16[b]	48	20
Mixed sagebrush	0	0	0	0	11	41[c]	10	7
Lakebed	1	0	<1	0	5	3	6	27
Basin big sagebrush	1	0	<1	0	3	6	3	7
Mountain big sagebrush	27	23	23	32	<1	0	0	0
Low sagebrush-fescue	6	31[c]	6	35[a]	0	0	0	0
Grassland	14	15	9	10	<1	0	0	0
Mountain shrub	6	0	7	10	0	0	0	0
Meadow	9	12	3	3	1	3	1	13
Juniper/Aspen	1	0	6	0	<1	0	0	0

[a] Analysis of cover type use was not possible for randomly observed broods at Jackass Creek because each cover type had less than 5 observations.

[b] Use less than expected ($P < 0.05$).

[c] Use greater than expected ($P > 0.05$).

Appendix I. Habitat characteristics at random locations and at sites used by hens with broods observed on transects and observed randomly at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney counties, 1989-1991. Means with the same letter or with no letter within study areas for each habitat characteristic are not different ($P > 0.05$).

	Hart Mountain			Jackass Creek		
Characteristic	Random (n=106) $\bar{x}$(SD)	Transects (n=32) $\bar{x}$(SD)	Random Broods (n=26) $\bar{x}$(SD)	Random (n=185) $\bar{x}$(SD)	Transects (n=32) $\bar{x}$(SD)	Random Broods (n=15) $\bar{x}$(SD)
Forb cover (%)	13(12)	11(9)	12(6)	10(10)	7(9)	8(12)
Grass cover (%)	16(10)	14(8)	15(8)	10(12)	10(9)	8(4)
Shrub cover (%)						
Short (0-40 cm)	12(11)	13(9)	11(7)	15(13)	15(10)	19(10)
Medium (41-80 cm)	5(9)	2(5)	5(8)	6(7)	9(10)	5(7)
Tall (>80 cm)	1(2)	1(1)	0	4(8)A	1(2)B	1(3)B

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J. Barnett

"Diet and nutrition of female sage grouse during the pre-laying period." Cooperators: Oregon Department of Fish and Wildlife and Oregon State University. (completed-September 1992).

K. Coggins

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A. DeLong

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M. Drut

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M. Gregg

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W. Pyle

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